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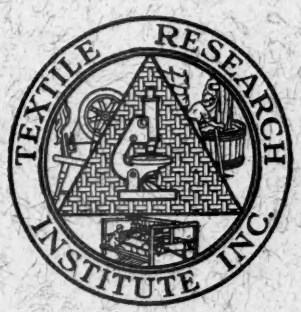

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TEXTILE RESEARCH JOURNAL

VOL. XVI, No. 7 July, 1946

The Role of Modern Science in Textile Technology*

Edward R. Schwarz†

For you, today, in Life's great book a chapter ends.
A new one waits beyond tomorrow's page,
Devoid as yet of word or chart by which to gage
The measure of your progress. What portends
The future? Will you find in formula and graph,
In test tube, whirling spool, or throbbing loom
The golden truth that will provide an epitaph
To finish the new work you now assume?

Weave well the threads of scientific lore
Into a pattern glorious and fine;
A fabric which shall be by your design,
Of blended elements, a cumulative store.
Combine as warp and weft the finest things
Each branch of science has to give;
For intellect beyond its data soars and brings
Perfection to the volume that you live!

—E. R. SCHWARZ

IT has been well said that life is understood only backward, but that it is lived forward. A glimpse at the past is justifiable, then, as a preface to prediction for the future. What is the record of science and of engineering over nearly a hundred years?

Let us consider the twenty years from 1860 to 1880. It was the golden era of civil engineering, with its development of canals and railroads. During the years from 1880 to 1900 there was pioneering by the electrical engineer and the scientist working with electricity, as exemplified by Edison in his development of the electric light and by Bell with his invention of the telephone. Again, from 1900 to 1920 we see the mechanical engineer as a machine designer come to the fore with the work of Selden and Ford on the automobile and of the Wright brothers on the airplane. Then, 1920 to 1940 brought the chemical engineer to the front, with the new importance of petroleum, rubber, glass, paper, and plastics. The present double decade bids fair to unite most of these branches of engineering and to add to their union the sciences of chemistry, physics, biology, and mathematics.

Wartime production in all lines evidenced the efficiency of such integrated cooperation. The production of the atomic bomb, with its corollaries of atomic energy production and control, ushers in a whole new era for the human race; it forcibly demonstrates the tremendous power of accomplishment when all branches of science and engineering join hands.

Such an era, though on a smaller scale, is ahead for textile technology. The textile industry is beset by problems, the answers to which can be given by physicist, chemist, statistician, botanist, biologist, and

* Commencement address, Lowell Textile Institute, May 17, 1946.

† Professor of Textile Technology; in charge, Textile Division, Massachusetts Institute of Technology.

engineer if they will work together and if the industry will give them thoughtful attention.

We think of resin-bonded yarn as a new development of considerable interest and importance. So it is. But it is only patterning a man-made yarn after what nature has done for centuries in making fibers. For cells—each behaving much like a tiny fiber—are fastened together in wool, in flax, and hemp, and jute. Cotton fiber itself is composed of fiberlike strands, or fibrils, which are not only twisted about the fiber axis but are bonded to each other as well.

For bonded yarn, the optimum resin must be furnished by the chemist and produced in commercial quantities by the chemical engineer. Certain of its properties and its behavior after application must be evaluated by the physicist. Its distribution in the yarn, both in location and amount, must be determined by the microscopist. The curing by dielectric heating must be worked out and controlled by the electrical engineer. The mechanical engineer must design and build the continuous-process machinery necessary for its proper application. After the properties of the unprocessed and of the processed yarns have been determined, the data must be analyzed by the statistician. The mathematician should be called in to analyze the geometry of the yarn structure. Even the psychologist may be asked to aid in evaluating the consumer reaction to the new material. Otherwise, the development will be incomplete.

The advent of man-made fibers may make the so-called "one fiber" mill obsolete. Similarly, the textile laboratory which attempts to operate with only one or two branches of science adequately represented is doomed to failure.

In the past, much of the testing of textiles was based upon the testing methods used for metals. In this work large loads are frequently encountered, while deformations are very small and are, in large part, instantly recoverable. For textiles, loads are not more than a few hundred pounds for usual work, and deformations may be as high as several hundred percent of the original gage length. In other words, textiles are essentially plastics in nature and should be studied as such. Thus the concept of change of length under constant tension or change in thickness under constant compression has come to be of considerable importance in modern textile technology. Tests performed under the conditions of a very slow rate of application of load are supplemented with tests at very high speeds. For example, a yarn or a cord may be ruptured by a steadily applied load of only 75 percent of its ultimate strength, if the load is left to act for several weeks; or it may fail in less than a thousandth of a second under impact. In either case, electronic equipment is found to be the best means of studying and recording what happens. The photoelectric potentiometer and the oscillograph become standard items of laboratory equipment. Photocells and vacuum tubes are regularly used and servo mechanisms are coming into use for many purposes.

The memory possessed by fibers is found to be of consequence to research worker and manufacturer alike, and both are increasingly aware of the profound effect of molecular constitution and orientation upon the physical and chemical properties of textiles. For this reason, the x-ray diffraction apparatus, the polarizing microscope, and the electron microscope are required. The textile technologist has progressed far beyond the era in which he was known as little more than a "rag puller." In many a textile research laboratory measurements of ultimate breaking strength have given way to determinations of energy absorption, resilience, flexibility, heat transmission, air permeability, creep and creep recovery, the mechanism of moisture and dye absorption, and the effects of repeated stress application.

Recent developments on statistical methods have made possible much better sampling procedure, more precise determinations of variability, significance, and of correlation. Analysis of variance alone has provided the textile researcher with an extremely useful and powerful tool for operating upon properly obtained data. Instead of considering the properties of a single specimen or of a few specimens, the frequency distribution of properties is found to be a more satisfactory means of study. This presupposes a working background in the theory of probability. Once facility in the use of arithmetic and simple geometry would suffice for the textile technologist. Now this knowledge must be supplemented by a knowledge of trigonometry, calculus, and differential geometry. Once the textile engineer was satisfied to use a stop watch and a simple tachometer. Now he studies the behavior of textile machinery in motion by means of the stroboscope and the ultra-high-speed camera. Once he was satisfied with ordinary photographs. Now he uses polaroid vectographs in three dimensions. Once the engineer designed mechanical guards to render safe the operation of machinery. Now he employs all the techniques of applied psychology, aptitude testing, and motion

study to fit the employee most efficiently and safely for the task which he must perform. He recognizes the importance of the human equation in safe and efficient mill operation. In the laboratory the same approach is coming in. The technician is increasingly interested in the consumer reaction to the performance of the material he is studying. He realizes increasingly, as does the manufacturer, that what the mill is selling is not yarn or fabric so much as consumer satisfaction. Hence he turns to such tasks as the evaluation of the "hand" of a fabric. He designs equipment for testing and measuring the "drape" of cloth. He spends hours surrounded by electronic apparatus of every kind to measure the speed with which fibers tire under reproduction of service conditions. Relaxation of load under constant deformation, he calls it, but it is just another example of the intelligent use of modern scientific knowledge in textile research.

The young man or woman entering the field of textile research, therefore, needs thorough grounding in the fundamentals of science and of engineering, and must develop a respect for and an active appreciation of the specialized sciences as well. The young man or young woman entering the textile industry itself must have breadth of vision great enough to see how much each branch of science can contribute and should be willing and anxious to adopt and adapt the products of research, for research is the key to accomplishment. Dr. Vannevar Bush, in the foreword to a book * on the progress of textile research (to which your own Professor H. J. Ball was a leading contributor and on the board of editors of which Dr. Louis Olney served), points out that while for its size, importance, and age the textile industry should be an outstanding exponent of the research method, it is not; that more research is probably going on in communications, or academic physics, or even in such a minor field, comparatively speaking, as refrigeration than in the central field of textiles. As reasons for this condition, Dr. Bush notes a distrust of the research method on the part of many textile men and the fact that the industry is made up of a large number of comparatively small units, no one of which thinks it can afford to pay the price of a comprehensive research program. While there is some basis in fact for this reasoning, yet research is still a necessity because of changing conditions and because it is impossible for a mill to remain static and stay in business at the same time. Dr. Bush states that there is no choice as to whether we change with changing world conditions; only whether we change rapidly enough and sanely enough to remain a part of the essential scheme of things.

To this end, research should be properly conducted, its facilities suitably located, and it should be adequately supported in much of its work on a cooperative basis. Dr. Bush is emphatic that a research laboratory cannot be bought ready-made from the scientific supply houses, or created overnight by hiring a scientist with a doctor's degree and turning him loose. A well-thought-out program is necessary, and, above all, experienced direction and trained personnel.

Textile education, then, fails in its entire purpose when it turns out a graduate who has not at least caught a glimpse of the possibilities that lie ahead in industry; who is not capable of intelligent planning; who is inadequately equipped with the necessary knowledge of and skill in handling the varied tools of technology and research.

The limited training for textile men which considers only the construction and methods of operating cotton- or wool-working machinery alone—or even of all types of textile machinery—is no longer adequate. They must have sound grounding in mechanics, electricity, physics, chemistry, mathematics, and the social sciences. The graduate from a textile institute must be able to use these tools intelligently. His imagination should have been stimulated so that he can forge ahead, free of preconceived limitations. He must be able to adopt and to adapt each new contribution of science wherever he can see a possible application. To handle fibers which are microscopic in two of their dimensions by means of the rollers, the sharpened wires, the leather aprons, the clumsy laps, the awkward cans, as we have done for generations, is questionable efficiency. For this is an age of increasing knowledge and understanding of aerodynamics and of electronics. To be satisfied that no better ways than those now in use can be evolved is the height of folly. Airborne planes are commonplace. Airborne fibers should be more fully studied. We know much about how various shapes behave when acted upon by air currents. Can we not spend some time in studying how certain scientifically engineered shapes can be used to control air currents and make them really efficient conveyers for

* *Textile Research—A Survey of Progress.* Compiled by the United States Institute for Textile Research, Inc. Technology Press, Massachusetts Institute of Technology, Cambridge, Mass., 1932.

individual fibers? In machine after machine, we spend time, money, and power on condensing fibers into masses which can be handled according to our present techniques—only to make every effort in the next machine to separate them into individuals again. For the most part, we handle tufts of fiber. We draw out masses of fiber time and time again by means of drafting rolls, hoping to achieve a uniform yarn. And yet the standard alibi of the testing laboratory, when it is called upon to justify some apparent lack of precision in method or equipment, is that "the variability of the yarn does not warrant any better method."

We should feed fibers into yarns almost one at a time, until there are the same number at each yarn cross section, similarly placed and arranged for optimum service. It is not too much to hope that sometime this may be done. Perhaps the dielectric properties of the fibers which we now curse because of the evils of "static" may be the very ones which will make it possible to separate each fiber from its neighbor without beating it half to death in pickers, or almost tearing fibers limb from limb in cards.

Many technical questions must be answered which we cannot answer now. We agree that the friction between the fibers holds a staple-fiber yarn together. We agree that this friction force is the product of the normal pressure between fibers multiplied by the coefficient of fiber-to-fiber friction—but—we do not know the magnitude of this normal pressure. We do not know how to compute it, or how to measure it directly. We do not know how many fiber-to-fiber contacts there are in a yarn, or what the nature of these contacts may be. Nor do we know the static coefficient of friction between fibers. Our fibers are plastic in nature, but we lack much information as to the properties of such plastics as these, and we sorely need assistance in the discovery and elucidation of the laws which govern their behavior. The advent of nylon and vinyon as commercial fibers, as well as a host of others, makes this need all the more imperative now.

It is a sign of definite progress to have the newly established plastics research group at M. I. T. integrated with the Textile Division in a joint program of research. Such integration of closely allied fields should occur increasingly in all of our educational institutions where textile technology is taught.

The chemist has made lasting and unquestionably great contributions to textile research and manufacture. He must be joined by the physicist and the engineer, for no longer can a dividing line be drawn between these fields. Both must join with other scientists, economists, and with the active management of the textile industry to do several important things. They must first interpret the findings of scientific research, both new and old to industry, so that it may be put to use. They must seek additional information in the light of modern science and by means of its latest and best techniques and equipment. Executive management can provide this kind of insurance against obsolescence by encouraging training in educational institutions such as yours, through the immediate establishment of scholarships and fellowships and of grants-in-aid for research to be performed by these students in the course of their work and by the staff members who supervise it. In no better way can an educational program be kept alive and up to date.

You who have been trained in the fundamentals of textile technology in its various forms, and who have, in addition, a growing appreciation of the scientific methods of research, can be of very real service to your chosen profession. You can set higher standards for it. You can aid in the work of research which must be done in the years ahead. You can help immeasurably in making the results of research understandable to mill management. The need is great. The field is wide. The reward is incalculable to you and to the industry you serve.

Statistical Methods for Equilibrium Moisture Correlations

P. J. McCarthy,* R. K. Toner,† and J. C. Whitwell ‡

Textile Research Institute and Princeton University

In the first paper of this series § there was presented a method for the treatment of equilibrium moisture data for textile fibers. Results of extensive statistical calculations were reported and analyzed. This paper presents the details of the methods which were used in arriving at those correlations.

Of major interest is a means of calculating the best point of intersection of a series of lines and of evaluating the probability of the existence of such a common point on all lines. When it is suspected that the lines are parallel, the test of probability must be adapted to this eventuality.

In general, the probabilities are estimated by analysis of variance. In this calculation, the individual lines are fitted to the experimental points by the method of least squares. They are then again fitted to the points with the additional condition of intersection or parallelism, whichever is thought to be more likely. The additional variance imposed by the added condition is then compared to that of the deviations from the simple individual least-squares lines and evaluated for probability by Snedecor ratios.

Illustrative graphical material based on the Wiegerink data for degummed silk in positive sorption from dry condition to equilibrium state is presented to show the various procedures.

Introduction

Although there have been previous attempts [2, 4, 5] to correlate the moisture regain of textile materials in such a way that existing data could be satisfactorily extrapolated and interpreted, they were subject to difficulties because of the nonlinearity of the resulting plots. In a recent paper, two of the present authors [6] have shown that an Othmer-type plot is well suited to the presentation of moisture regain data. It is the purpose of this publication to outline in some detail the statistical methods required in that analysis.

The Clausius modification of the Clapeyron equation was noted to be the starting point in the method, namely:

$$\frac{dP^\circ}{dT} = \frac{P^\circ \lambda}{RT^2}. \quad ** \qquad (1)$$

As written, the superscript on the vapor pressure term refers to the reference material, in this case pure water, the latent heat of which at the absolute temperature, T, is represented by λ. If the equation is written again with reference to the equilibrium vapor pressure of water over fiber and if this expression is divided by the first at a condition of constant temperature, the result is

$$\frac{dP/P}{dP^\circ/P^\circ} = \frac{d \ln P}{d \ln P^\circ} = \frac{\Delta H}{\lambda}. \qquad (2)$$

ΔH refers to the total heat effect of removal or addition of moisture from or to the fiber. Integrating equation (2),

$$\log P = \frac{\Delta H}{\lambda} (\log P^\circ) + \text{Constant}. \qquad (3)$$

It is clear that if ΔH and λ are similarly affected by temperature, a plot of P versus P° on logarithmic coordinates will give a straight line for each condition of constant moisture regain.

Since the original data were not in proper form for this correlation, they were plotted as shown in Figure 1, with smooth curves drawn through the

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§ "Correlation of Equilibrium Moisture Data," by Whitwell and Toner, appeared in the June issue, page 255.

** For Symbols, see page 308.

experimental points. It might appear that using data from smoothed curves would improve the accuracy of the statistical analysis, but this is not necessarily true when, as in this case, the smoothing is done visually. The operation is undesirable but unavoidable, since the data were not taken with this particular correlation in mind. At positions of constant moisture the relative humidities were noted on the various isotherms. These relative humidities were converted to P values by multiplying each by the vapor pressure of pure water ($P°$) at that temperature. To complete the tabulation shown in Table I, which provides the essential material for the statistical calculations, four-place logarithms of P and $P°$ values were recorded.

The values of P and $P°$ may be plotted on log-log paper as in Figure 2, giving the straight lines predicted by equation (3). The method of least squares, to be discussed later, was used in determining the equations of these lines.*

* SYMBOLS:

F—Snedecor ratio of variances
ΔH—heat effect of sorption process, calories per gram molecule of water
P—vapor pressure of water over fibers, mm.Hg
$P°$—vapor pressure of pure water, mm.Hg
R—universal gas constant
S_1^2—sum of squares of deviations of experimental points from least-squares line (or lines)
S_2^2—sum of squares of deviations of experimental points from best lines when a condition additional to experimental points is imposed
T—temperature, degrees Kelvin
a—y intercept of the straight line, $y = a + kx$
k—slope of straight line, $y = a + kx$
n—number of experimental points
r—number of constant regain lines
x—log $P°$
y—log P
λ—latent heat of evaporation of water, calories per gram molecule
σ—standard deviation

$\sum_{\alpha=1}^{n_i}$—summation for all points on one line $= \sum_{\alpha}$

$\sum_{i=1}^{r}$—summation for r lines of the summations on each line $= \sum_{i}$

Superscripts and Subscripts:

$\bar{}$—indicates average of n values $\left(\text{i.e., } \bar{x} = \frac{\sum x}{n}\right)$
$\hat{}$—indicates estimate of a quantity as determined by statistical calculations
1, 2, ... α . . . .—any one point on a given line
1, 2, ... i . . . .—any one line of a group of lines
$_o$—on x and y indicates a chosen value of the coordinates of the common point
n_i—the nth point on the ith line

It will be observed that, although equation (3) indicates that log P should be plotted as ordinate against log $P°$ as abscissa, Figure 2 reverses these coordinates, a procedure dictated by the characteristics of commercial graph paper. Log P has, however, been designated by the usual mathematical symbol for ordinate, y, with log $P°$ as x.

Theory of Common Point

An examination of the data for varieties of fibers when treated in the manner described in the preceding section reveals that as moisture regain decreases, the slope (dy/dx) increases, thus suggesting the possibility that if the constant-regain lines were extended they might intersect in a common point. The location of the common point has both theoretical significance and practical value. In the previous paper [6] its horizontal location with respect to the water reference line (log $P°$ versus log $P°$) was used as a means of characterizing the sorbing material (e.g., fibers, silica gel, aqueous solutions). The vertical location, or distance along the water reference line, was interpreted as a function of the heat effects of sorption. It was also shown that a fixed ratio exists between the coordinates of the common points in the opposite processes of sorption and desorption. Prediction of such points will be shown in a subsequent paper to be of value in estimating the entire family of moisture curves with a minimum amount of data.

The accurate determination, graphically, of such an intersection is impossible, first, since the point invariably proves to be far beyond the region of the experimental data and, second, because minor experimental errors preclude the intersection of all least-squares lines exactly at one point. Accordingly, a mathematical method is essential. The principle of least squares for the individual lines and the analysis of the increase in variance caused by passing each line through the best common point is a solution. The method is designated as analysis of variance.

Determination of Common Point

Suppose that for a given fiber there are data for r different moisture regains, there being seven in the example shown, 2, 3, 4, 5, 6, 7, and 8 percent regain. Then, if the r different lines are to pass through the common point (x_o, y_o), the equation of the ith line

TABLE I. DATA DERIVED FROM FIGURE 1

Moisture regain (%)	35.4°C	70°C	100°C	125°C
		Relative humidity (%)		
2	—	13.3	21.4	27.9
3	—	24.4	35.0	41.5
4	21.6	35.1	47.3	—
5	31.4	45.2	57.8	—
6	39.8	54.6	66.5	—
7	47.3	62.8	73.7	—
8	54.6	70.2	79.1	—

	Vapor pressure data (mm.Hg)							
	35.4°C	70°C	100°C	125°C	35.4°C	70°C	100°C	125°C
	Vapor pressure of pure water							
	$P = P^\circ \times$ relative humidity				Logarithms of P and P°			
	43.46	233.7	760.0	1741	1.6371	2.3687	2.8808	3.2407
	Vapor pressure of water over fiber							
Moisture regain (%)								
2	—	31.08	162.6	485.7	—	1.4925	2.2111	2.6863
3	—	57.02	266.0	722.5	—	1.7561	2.4249	2.8588
4	9.366	82.03	359.5	—	0.9716	1.9140	2.5557	—
5	13.62	105.6	439.3	—	1.1341	2.0237	2.6428	—
6	17.26	127.6	505.4	—	1.2370	2.1059	2.7036	—
7	20.51	146.8	560.1	—	1.3120	2.1668	2.7483	—
8	23.67	164.1	601.2	—	1.3742	2.2151	2.7790	—

$(i = 1, 2, \ldots r)$ is

$$(y_i - y_o) = k_i(x_i - x_o), \tag{4}$$

where k_i is the slope of the line. If there are n_i experimental points for determining the ith line (three for any line in the example shown), namely, $(x_{i1}, y_{i1}), \ldots (x_{i\alpha}, y_{i\alpha}), \ldots (x_{in_i}, y_{in_i})$, the principle of least squares says k_i, x_o, and y_o should be determined so that the sum of squares of the deviations, $y_{i\alpha} - y$, is a minimum. This sum of squares may be written

$$\sum_{i=1}^{r}\sum_{\alpha=1}^{n_i}(y_{i\alpha} - y)^2$$

$$= \sum_{i=1}^{r}\sum_{\alpha=1}^{n_i}[(y_{i\alpha} - y_o) - k_i(x_{i\alpha} - x_o)]^2. \tag{5}$$

Differentiating this expression with respect to k_i, x_o, and y_o, and equating the resulting quantities to zero, the following equations are obtained.

From the partial with respect to k_i, solved for k_i:

$$k_i = \frac{\sum_{\alpha=1}^{n_i}(x_{i\alpha} - x_o)(y_{i\alpha} - y_o)}{\sum_{\alpha=1}^{n_i}(x_{i\alpha} - x_o)^2}. \tag{6a}$$

Equating the partial with respect to x_o:

$$\sum_{i=1}^{r}\sum_{\alpha=1}^{n_i}k_i[(y_{i\alpha} - y_o) - k_i(x_{i\alpha} - x_o)] = 0. \tag{6b}$$

Equating the partial with respect to y_o:

$$\sum_{i=1}^{r}\sum_{\alpha=1}^{n_i}[(y_{i\alpha} - y_o) - k_i(x_{i\alpha} - x_o)] = 0. \tag{6c}$$

Because of their complexity these equations cannot be solved directly to obtain the values of k_i, x_o, and y_o which minimize equation (5). Under such circumstances, the usual procedure is to use either an iterative method to obtain solutions for equation (6), or to replace x_o, y_o, and k_i in equation (5) by the first two terms of a Taylor-series expansion before carrying out the minimization. However, in the present instance both methods appear unsuitable because of the difficulty which would be entailed in selecting good initial approximations for x_o, y_o, and k_i. Consequently, it was decided to avoid this difficulty by the use of a graphical representation of the problem. The details of this solution follow, as well as the results obtained by its use on the data with which this paper is concerned.

The value of k_i given in equation (6a) is substituted in the sum of squares (equation (5)), thus

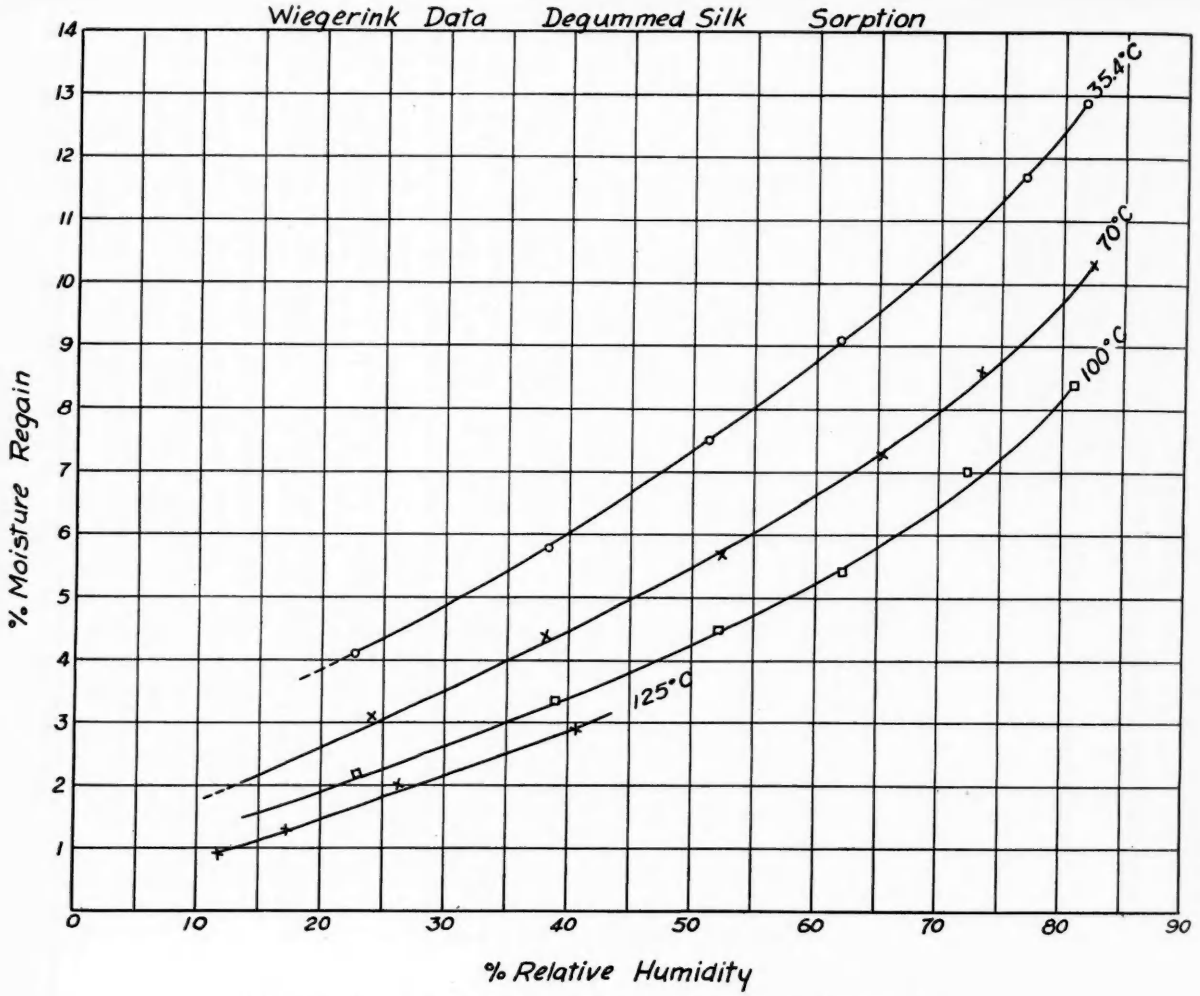


FIG. 1. *Degummed silk in sorption. Original data of Wiegerink.*

obtaining *

$$\sum_i \sum_\alpha \left[(y_{i\alpha} - y_o) - (x_{i\alpha} - x_o) \frac{\sum_\alpha (x_{i\alpha} - x_o)(y_{i\alpha} - y_o)}{\sum_\alpha (x_{i\alpha} - x_o)^2} \right]^2 . \quad (7)$$

Simplifying,

$$\sum_i \left[\sum_\alpha y_{i\alpha}^2 - 2y_o \sum_\alpha y_{i\alpha} + n_i y_o^2 - \left\{ \frac{(\sum_\alpha x_{i\alpha} y_{i\alpha} - y_o \sum_\alpha x_{i\alpha} - x_o \sum_\alpha y_{i\alpha} + n_i x_o y_o)^2}{\sum_\alpha x_{i\alpha}^2 - 2x_o \sum_\alpha x_{i\alpha} + n_i x_o^2} \right\} \right] . \quad (8)$$

* In the remaining equations the summations will be simplified as follows:

$$\sum_{i=1}^{r} = \sum_i ; \qquad \sum_{\alpha=1}^{n_i} = \sum_\alpha .$$

This expression, denoted by S_2^2, will attain its minimum value if x_o and y_o are chosen in accordance with the other two parts of equation (6). For any other pair of values (x_o, y_o) it will be greater.

In the solution used, a range of x_o values was chosen arbitrarily. If a particular one of these x_o values is substituted in equation (8), S_2^2 is a second-degree polynomial in y_o. Thus, on S_2^2–y_o coordinates a parabola can be readily sketched by assigning successive values to y_o. The axis of this parabola is parallel to the S_2^2 axis, and enough values of y_o must be taken so that the minimum value of S_2^2 for this particular x_o value is determined. A set of these parabolas for degummed silk in sorption is shown in Figure 3. If any line $S_2^2 = a$ is now drawn, the intersections of this line with the parabolas define the coordinates of the points needed to sketch a "confidence ellipse," which is discussed

below. The minimum value of S_2^2 is readily seen to be determined by the minimum point on the locus of the minima of the individual parabolas. The best of all possible x_o and y_o values are determined by this method and these best values will be designated as $(\hat{x}_o, \hat{y}_o)$. Experience has shown that the procedure of sketching the "confidence ellipse" leads to a closed curve in the x_o–y_o plane, although this curve is not necessarily an ellipse. This fact is not immediately evident from expression (8) even though a direct analysis of (8) might possibly be used to demonstrate its truth. Substitution of $(\hat{x}_o, \hat{y}_o)$ in the expression for k_i in equation (6) gives the least-squares estimates of the slope of each line through the point, namely,

$$k_i = \frac{n_i\hat{x}_o\hat{y}_o + \sum_\alpha x_{i\alpha}y_{i\alpha} - \hat{y}_o\sum_\alpha x_{i\alpha} - \hat{x}_o\sum_\alpha y_{i\alpha}}{n_i\hat{x}_o^2 + \sum_\alpha x_{i\alpha}^2 - 2\hat{x}_o\sum_\alpha x_{i\alpha}}. \quad (9)$$

Using the r lines determined in this fashion from the data, the steps may be retraced by simple computation to obtain computed curves analogous to those shown in Figures 1 and 2. Such calculated curves are shown in Figures 5 and 4, respectively, the points in the former representing the original experimental data.

Parallelism. One must be careful not to extend these calculations to extremes. As has been pointed out in the previous paper [6], at very low regains the mechanism of sorption changes to pure adsorption. Since every molecule added to the fiber is then attached as is every preceding molecule, the heat effects are constant for all regain lines in this region and the lines of constant moisture regain will be parallel. Such is the case for the data of Neale and Stringfellow [2] shown in the previous paper and repeated in Figure 6. There is also the possibility of an upper limit since abnormal structural changes in the fiber may develop under very high moisture conditions, although no concrete evidence is found in any of the data analyzed. However, it is difficult, if not impossible, to define exactly what is meant by high and low regains. For this reason, it would be desirable to have a statistical test to see how well any group of lines from a given set of data support the hypothesis that they pass through a common point or are parallel. Tests which are applicable to these problems will be discussed in the next sections.

It is usually possible to decide in advance of making calculations whether parallelism or intersection is to be expected. On the basis of the range of moisture regain, decision should be made as to the proper test which should then be applied as detailed later. If the test indicates that the hypothesis in this form is unlikely, the test for the other form may be applied. If that test also shows significance, it is presumed that the condition repre-

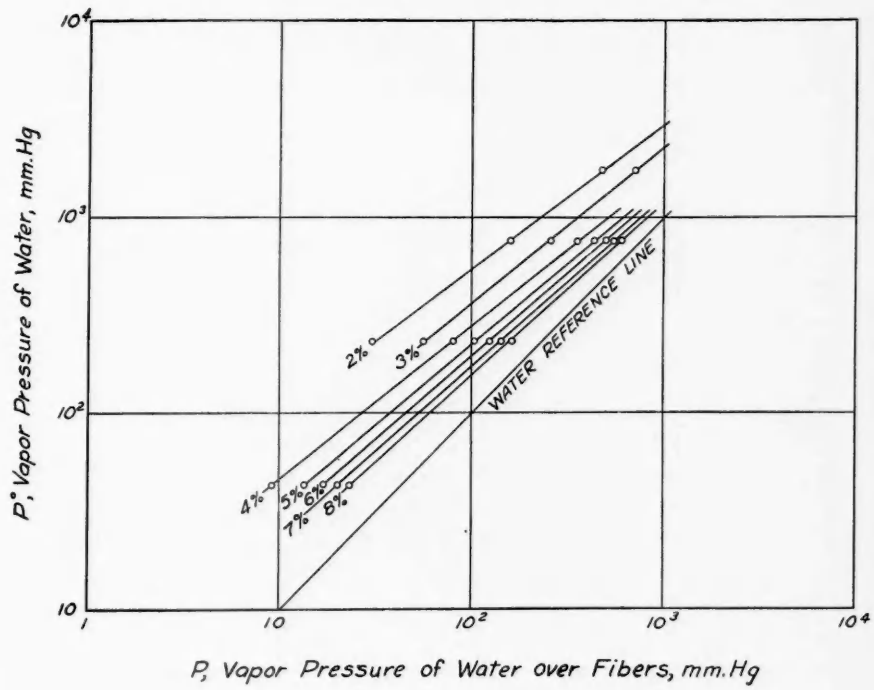


FIG. 2. *Othmer plot derived from Figure 1 (see Table I).*

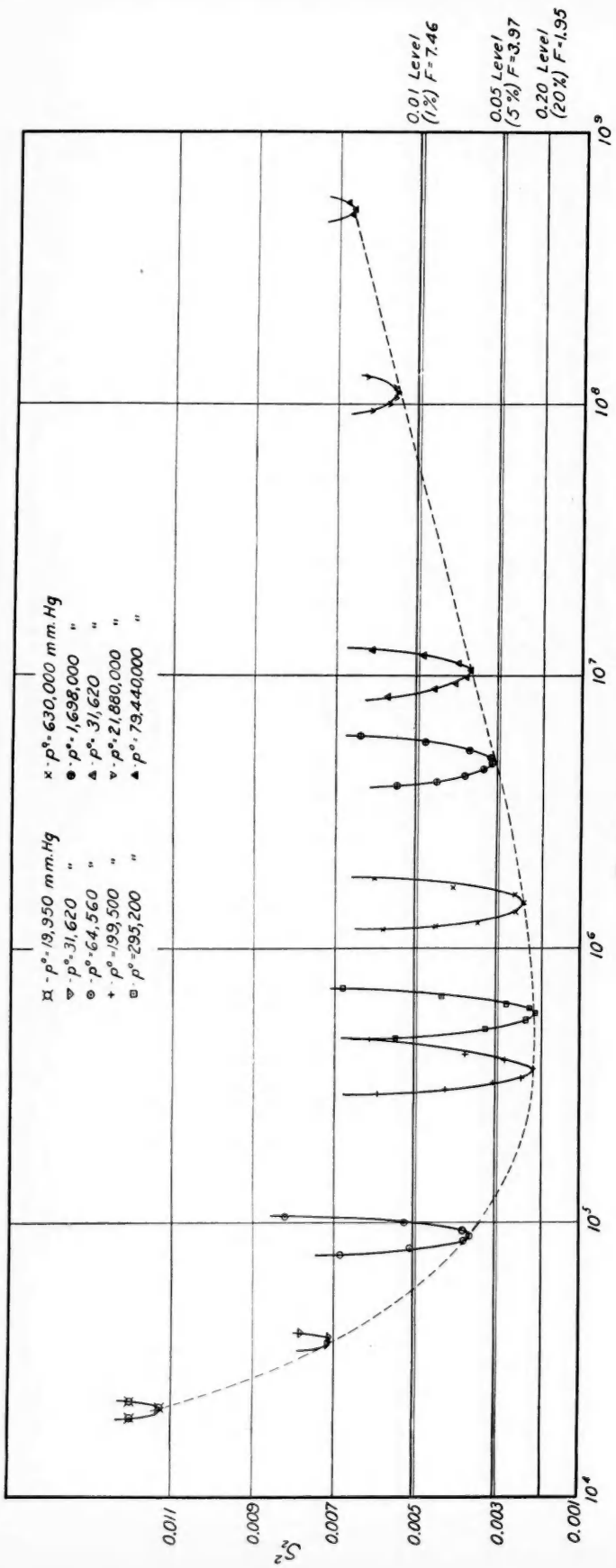


FIG. 3. S_2^2 *versus* y_0 *diagram for the determination of common point and "confidence ellipse."*

sented by the data falls in a transition region (that is, between parallelism and intersection). The first hypothesis which is not refuted by the data is taken as the working hypothesis. This procedure is admittedly a practical expedient, and it is hoped that a more precise method of making a decision can be devised in the future.

Testing Statistical Significance

As in the preceding section, consideration at any time is of data on one fiber in one process of sorption or desorption. The data for the ith line of constant moisture condition consist of the n_i points $(x_{i1}, y_{i1}), \ldots . (x_{i\alpha}, y_{i\alpha}), \ldots . (x_{in_i}, y_{in_i})$, where x and y are as previously defined. Continuing to assume that the data for each moisture condition can be represented by a straight line, the hypothesis that these lines intersect in a common point should be tested.

The usual assumption under such circumstances is that, for a particular x value and moisture condition, say the ith, the measured quantity y_i has a normal (Gaussian) distribution with mean $y_i = a_i + k_i x$ and variance σ_i^2. That is, the distribution of y_i, given x, is

$$\frac{1}{\sqrt{2\pi}\sigma_i} e^{-\frac{1}{2\sigma_i^2}(y_i - a_i - k_i x)^2} dy_i. \quad (10)$$

The values of a_i and k_i, as determined from the observed points $(x_{i1}, y_{i1}), \ldots . (x_{i\alpha}, y_{i\alpha}), \ldots . (x_{in_i}, y_{in_i})$ are given by the least-squares equations

$$\sum_\alpha y_{i\alpha} = n_i a_i + k_i \sum_\alpha x_{i\alpha}; \quad (11a)$$

$$\sum_\alpha x_{i\alpha} y_{i\alpha} = a_i \sum_\alpha x_{i\alpha} + k_i \sum_\alpha x_{i\alpha}^2. \quad (11b)$$

Denoting the solutions of these equations by $\hat{a}_i$ and $\hat{k}_i$, the sum of squares of the deviations about the least-

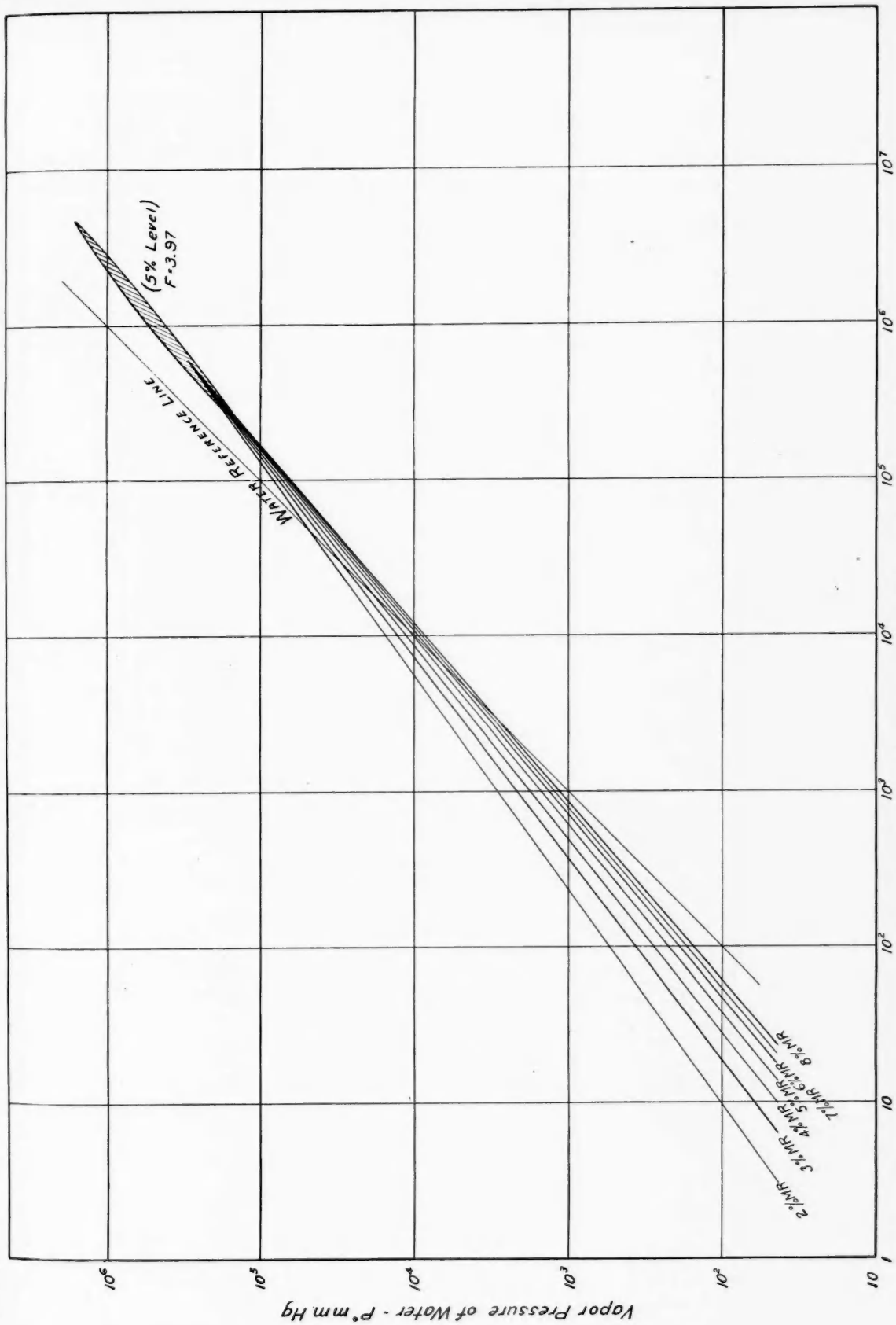


FIG. 4. *Recalculated Othmer plot based on common point determined in Figure 3.*

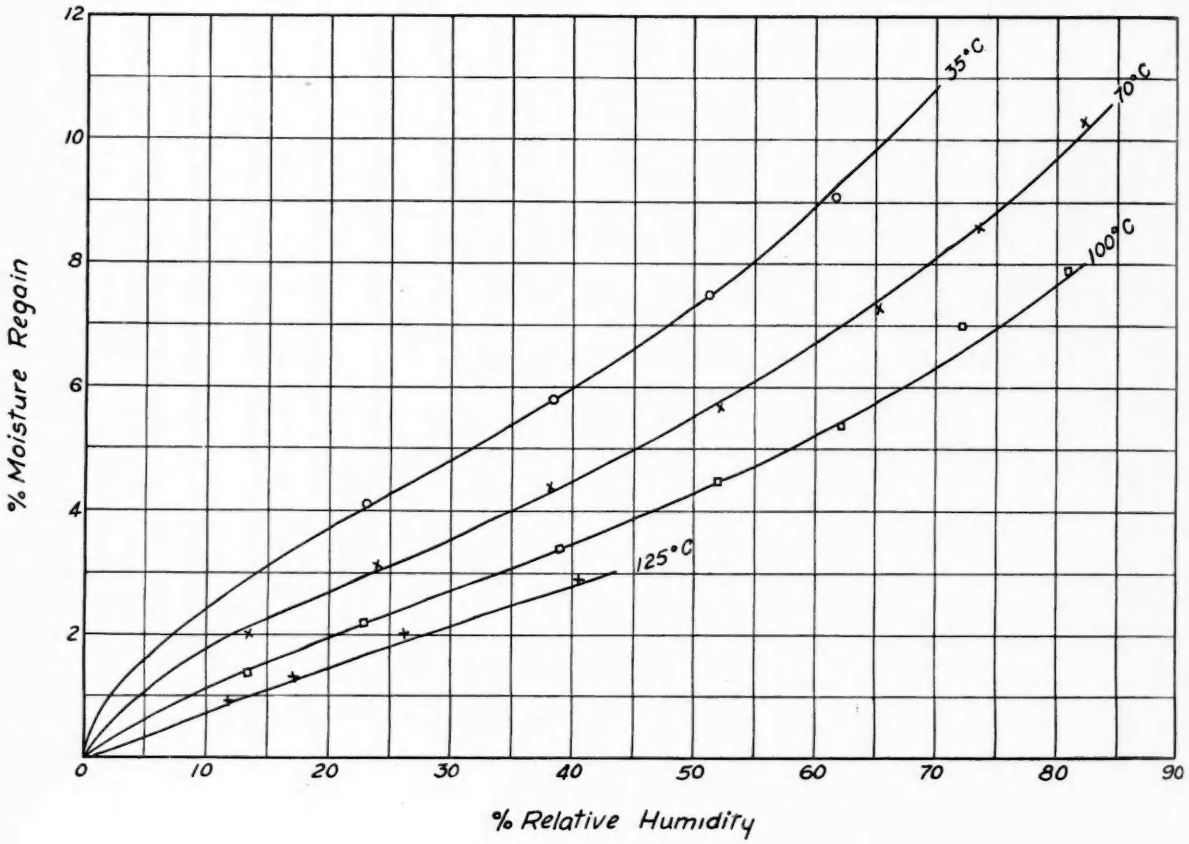


FIG. 5. *Recalculated isotherms with original data included.*

squares line, S_{1i}^2, is given by

$$S_{1i}^2 = \sum_{\alpha} (y_{i\alpha} - \hat{a}_i - \hat{k}_i x_{i\alpha})^2$$

$$= \frac{1}{n_i}\left\{ n_i \sum_{\alpha} y_{i\alpha}^2 - (\sum_{\alpha} y_{i\alpha})^2 - \frac{[n_i \sum_{\alpha} x_{i\alpha} y_{i\alpha} - (\sum_{\alpha} x_{i\alpha})(\sum_{\alpha} y_{i\alpha})]^2}{n_i \sum_{\alpha} x_{i\alpha}^2 - (\sum_{\alpha} x_{i\alpha})^2} \right\}. \quad (12)$$

With the condition as described in the preceding two paragraphs, S_{1i}^2/σ_i^2 is distributed like chi-square (χ^2) with $(n_i - 2)$ degrees of freedom. Furthermore, using the additive properties of χ^2,

$$S_1^2 = \sum_{i=1}^{r} S_{1i}^2/\sigma_i^2 \quad (13)$$

is distributed like χ^2 with $(\sum_i n_i - 2r)$ degrees of freedom. In most conditions of interest, the further assumption that $\sigma_1^2 = \sigma_2^2 = \ldots = \sigma_r^2 = \sigma^2$ is usually required if any statistical test is to be applied. This assumption can be tested on the basis of the observed data by methods for testing homogeneity of variance as given by Snedecor [3].

If all r lines pass through a common point (x_o, y_o), then the assumption is that y_i, for given x, has the distribution

$$\frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2\sigma^2}[(y_i - y_o) - k_i(x - x_o)]^2} dy_i, \quad (14)$$

where, again, it is assumed that $\sigma_1^2 = \sigma_2^2 = \ldots = \sigma_r^2 = \sigma^2$. If these assumptions are true, then S_2^2/σ^2, where S_2^2 is given by equation (8) with $\hat{x}_o$, $\hat{y}_o$, and $\hat{k}_i$ substituted for x_o, y_o, and k_i, is distributed like χ^2 with $(\sum_i n_i - r - 2)$ degrees of freedom. Statistical theory has shown that when the true lines actually pass through a common point, $S_2^2/\sigma^2 - S_1^2/\sigma^2$ is distributed like χ^2 with

$$(\sum_i n_i - r - 2) - (\sum_i n_i - 2r) = r - 2$$

degrees of freedom and, moreover, that it is dis-

tributed independently of S_1^2/σ^2. Consequently,

$$\left(\frac{S_2^2/\sigma^2 - S_1^2/\sigma^2}{S_1^2/\sigma^2}\right)\left(\frac{\sum_i n_i - 2r}{r-2}\right) \qquad (15)$$

is distributed according to the F distribution [3]. It will be noted that this ratio does not contain the unknown σ^2 which cancels, but only quantities which can be calculated from the observed data. If the F table, as given in Snedecor [3] or Fisher and Yates [1], is entered for $n_1 = r - 2$ and $n_2 = \sum_i n_i - 2r$ at the 0.01 level, a particular value F will be obtained. If the observed F value is greater than this value, there is less than one chance in one hundred that an F ratio this large would be obtained when lines actually pass through a common point. Consequently, the hypothesis of a common point is extremely unlikely. On the other hand, if the F ratio were smaller than the value at the 0.01 level, the data are not considered to refute the hypothesis of a common intersection point. Values for the 0.01 and 0.05 levels are given in both tables, and, in addition, Fisher and Yates give values for the 0.20 level. Values of the Snedecor ratio for the case illustrated are

Level	Snedecor ratio, F
0.01	7.46
0.05	3.97
0.20	1.97

Instead of calculating F values for each chosen value of x_o, y_o, the values of S_2^2 at the various levels have been calculated from the F values and plotted in Figure 3. It is to these levels that the term "confidence" has been arbitrarily applied (as noted earlier). For the data involved, the assumption of homogeneity of variance is somewhat violated and therefore only semiquantitative inferences may be drawn from the F limits.

Test for Parallelism

The derivation of a statistical test for parallelism follows the same line of argument used in the last section. Making the fundamental assumptions of the preceding section, it is further assumed that the measured quantity y_i, for the ith moisture condition and a particular x value, has the distribution

$$\frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{1}{2\sigma^2}(y_i - a_i - kx)^2} dy_i. \qquad (16)$$

Upon the basis of these assumptions, the estimated values of $\hat{k}$ and $\hat{a}_i$ are found by least squares to be

$$\hat{k} = \frac{\sum_i \left[\sum_\alpha x_{i\alpha} y_{i\alpha} - \sum_\alpha x_{i\alpha} \sum_\alpha y_{i\alpha}/n_i\right]}{\sum_i \left[\sum_\alpha x_{i\alpha}^2 - \frac{(\sum_\alpha x_{i\alpha})^2}{n_i}\right]}; \qquad (17a)$$

$$\hat{a}_i = \frac{\sum_\alpha y_{i\alpha}}{n_i} - \hat{k}\frac{\sum_\alpha x_{i\alpha}}{n_i}. \qquad (17b)$$

Consequently, the estimated equation of the ith line is

$$(y - \bar{y}_i) = \hat{k}(x - \bar{x}_i). \qquad (18)$$

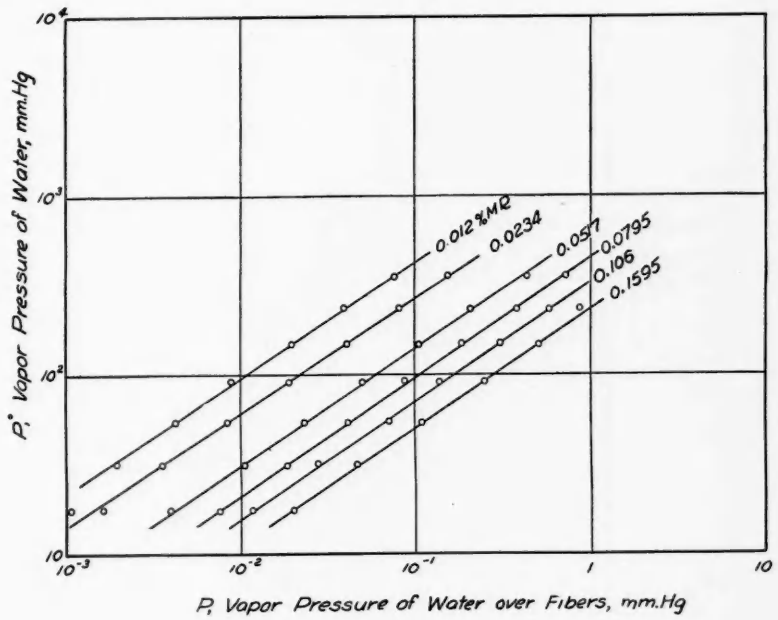


FIG. 6. *Data of Neale and Stringfellow for low regain on washed cotton in sorption.*

TABLE II.

MR (%)	$\sum_\alpha x_{i\alpha}$	$\sum_\alpha x_{i\alpha}^2$	$\sum_\alpha y_{i\alpha}$	$\sum_\alpha y_{i\alpha}^2$	$\sum_\alpha x_{i\alpha}y_{i\alpha}$	n	$(\sum_\alpha x_{i\alpha})^2$	$(\sum_\alpha y_{i\alpha})^2$	$(\sum_\alpha x_{i\alpha})(\sum_\alpha y_{i\alpha})$
2	8.4902	24.41188482	6.3899	14.33272715	18.61051404	3	72.08349604	40.83082201	54.25152898
3	8.4902	24.41188482	7.0398	17.13676466	20.40983915	3	72.08349604	49.55878404	59.76930996
4	6.8866	16.58984474	5.4413	11.13900505	13.48675872	3	47.42525956	29.60774569	37.47205658
5	6.8866	16.58984474	5.8006	12.36593634	14.26355154	3	47.42525956	33.64696036	39.94641196
6	6.8866	16.58984474	6.0465	13.27443677	14.80186891	3	47.42525956	36.56016225	41.63982690
7	6.8866	16.58984474	6.2271	13.96951913	15.19767700	3	47.42525956	38.77677441	42.88354686
8	6.8866	16.58984474	6.3683	14.51793465	15.50235339	3	47.42525956	40.55524489	43.85593478
						$\sum_i n_i = 21$			
						$r = 7$			

Least-squares calculations

S_1^2	Degrees of freedom	Variance
0.00020249	1	0.00020249
.00029708	1	.00029708
.00007360	1	.00007360
.00000295	1	.00000295
.00002520	1	.00002520
.00006472	1	.00006472
0.00013937	1	0.00013937

$S_1^2 = 0.00080541$

Each equation is solved for y (log P) at experimental values of x (log $P°$). The deviations of the experimental values of log P are calculated, squared, and the squares summed, and this value, S_2^2, is compared to the least-squares sum S_1^2 by the ratio

$$F = \left(\frac{S_2^2 - S_1^2}{S_1^2} \right) \left(\frac{\sum_i n_i - 2r}{r - 1} \right). \qquad (19)$$

The hypothesis of parallelism is not unlikely unless the value of F so obtained is greater than the tabular value of F at $n_1 = (r - 1)$ and $n_2 = (\sum_i n_i - 2r)$ degrees of freedom at the 0.01 level.

Precautions to be observed. It will be observed (Table II) that the calculations are recorded to eight decimal places. This may seem unnecessary in view of the fact that the derived data can be read from the charts to only three significant places and four-place logarithms were used in the basic calculations. However, it is soon obvious in this work that it is absolutely essential never to round off figures. Deviations are small and the sum of squares of the deviations from the "best" line may be better only in the seventh or eighth place from the sum of squares of the deviations from the line through the assumed point. If all figures are not retained, it is possible to get the mathematically impossible result of the assumed line appearing better than the "best" line.

There is another possible error which can easily be avoided. Inasmuch as the average deviation times the total number of points is equal to sum of deviations ($\bar{x}_i = \sum_\alpha x_{i\alpha}/n_i$), the formulas which are presented in this paper may be written in terms of average values rather than the summations consistently employed here. The division by n_i so represented should be postponed until the last possible moment, for unless the $\sum$ term is exactly divisible by n_i, a certain amount of inaccuracy will be introduced by rounding the last figure; again this is particularly true when there is close agreement of data with least-squares lines.

In this work, as in all cases where experimental data are being fitted to theoretically predicted line forms, careful scrutiny is essential to make certain that no consistent deviation exists which would indicate failure of the data to substantiate the theory. The current material has been carefully checked for increasing or decreasing deviations with decrease of temperature. No such tendency seemed to exist.

It is evident that statistical analysis is a powerful tool when applied to engineering data. This correlation would have been impossible without it. It is usually necessary, however, that the advice of a trained statistician be obtained in setting up the various criteria for tests, for there are many places where the unskilled can go astray. Properly ap-

plied, statistical analysis can be used not only to correlate data but also to determine what data are necessary to obtain a desired correlation. Although its use has been neglected in the field of chemical engineering, it is hoped that the present application may demonstrate its possibilities and suggest other uses of value.

Acknowledgment

The authors are indebted to J. W. Tukey, of the Mathematics Department, Princeton University, for helpful suggestions in the analysis.

Literature Cited

1. Fisher, R. A., and Yates, F., "Statistical Tables for Biological, Agricultural, and Medical Research," London, Oliver and Boyd, 1938.
2. Neale, S. M., and Stringfellow, W. A., *Trans. Faraday Soc.* **37**, 525 (1941).
3. Snedecor, G. W., "Statistical Methods," Iowa State College Press, 1946.
4. Urquhart, A. R., and Williams, A. M., *J. Text. Inst.* **15**, T138 (1924).
5. Walker, A. C., TEXTILE RESEARCH **13**, 15 (Mar. 1943).
6. Whitwell, J. C., and Toner, R. K., TEXTILE RESEARCH JOURNAL **16**, 255 (1946).

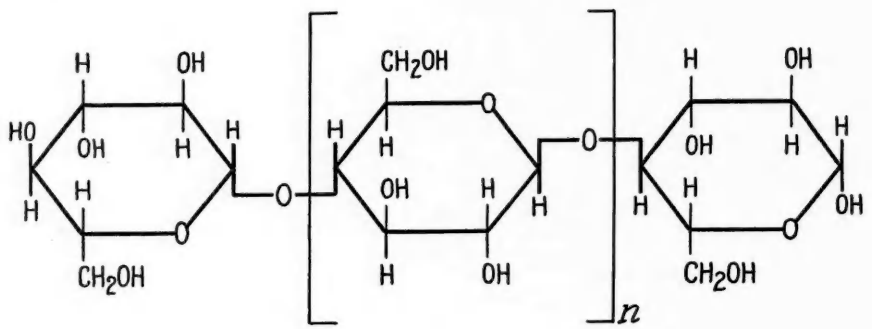
Cellulose Studies

V. Reducing End-Group Estimation: A New Method Using Potassium Permanganate*

Lejaren Arthur Hiller, Jr.,† and Eugene Pacsu

Contribution from The Textile Foundation and the Frick Chemical Laboratory at Princeton University

DETERMINATION of end-groups has been one of the important methods for measuring the molecular size of long-chain polymers. This can be done if there exists at either one or both ends of each chain a unique reactive group. Such is indeed the case with cellulose, which, according to the present-day accepted formula (I), represents a long chain of *β-D*-glucopyranose anhydride units joined by 1,4-glycosidic bonds. The nature of this structure leaves only the end-unit retaining its reducing power. This potential aldehyde group is shown on the far right of formula (I).



(I)

Many attempts have been made to cause this group to undergo a quantitative reaction. The majority of these efforts either involved an oxidation to carboxyl group (RCHO → RCOOH) or a condensation reaction typical of aldehydes in general.

A. Principal Methods Developed

The traditional means has been the "copper-number" determination. This was originally developed by Schwalbe [1] and has been modified frequently since. The essential reaction in all the variations of this method remains, however, the reduction in alkaline media of cupric ions, thus causing the formation of a red deposit of cuprous oxide, and the oxidation of the cellulose supposedly according to the above equation. The amount of red deposit is then measured by some means such as titration by oxidizing agents.

The "copper-number" method has been the target of much criticism. It has been found to be extremely sensitive to the conditions under which it is em-

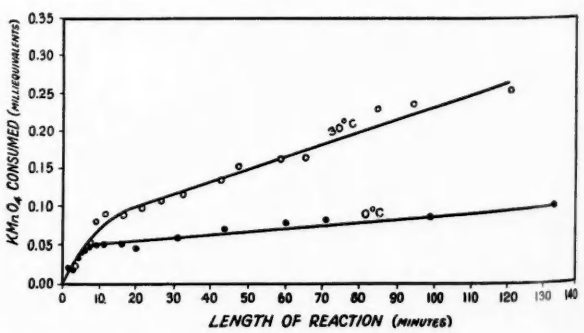


FIG. 1. *Milliequivalents of potassium permanganate consumed per gram of rayon versus length of reaction.*

* This is the fifth paper in a series—"Cellulose Studies." The other four have appeared in the October, 1945, and the March, April, and June, 1946, issues.

† Fellow of the Textile Research Institute.

TABLE Ia. REACTION OF RAYON WITH POTASSIUM PERMANGANATE AT 30°C

Reagents: 0.0673*N* potassium permanganate
0.0863*N* sodium oxalate
0.25*N* sulfuric acid

Sample No.	Length of reaction (min.)	Weight of sample (g.)	Total volume $KMnO_4$ added (ml.)	Volume $Na_2C_2O_4$ added (ml.)	Milli-equivalents $KMnO_4$	Milli-equivalents $Na_2C_2O_4$	Milli-equivalents oxygen used up	Milli-equivalents oxygen used per g. rayon
	—	—	30.09	23.48	2.025	2.026	−0.001	—
1	4.0	1.044	33.03	25.48	2.223	2.199	0.024	0.023
2	7.5	1.061	33.08	25.15	2.226	2.170	0.056	0.053
3	9.5	0.730	32.45	24.64	2.184	2.126	0.058	0.080
4	12.0	0.997	34.28	25.70	2.307	2.218	0.089	0.089
5	17.0	1.429	34.31	25.30	2.309	2.183	0.126	0.088
6	22.0	1.362	34.51	25.40	2.323	2.192	0.131	0.096
7	27.0	1.221	33.76	24.80	2.272	2.140	0.132	0.108
8	33.0	1.141	31.99	23.44	2.153	2.023	0.130	0.114
9	43.0	1.506	34.80	24.77	2.342	2.138	0.204	0.135
10	48.0	1.473	34.38	24.22	2.314	2.090	0.224	0.152
11	59.0	1.312	35.67	25.27	2.401	2.181	0.220	0.162
12	66.0	1.486	35.16	24.60	2.366	2.123	0.243	0.164
13	85.0	0.927	34.67	24.59	2.333	2.122	0.211	0.228
14	95.0	1.202	35.90	24.69	2.416	2.132	0.284	0.236
15	121.0	1.251	35.30	23.85	2.376	2.058	0.318	0.254

ployed. At the present time, the erratic results it gives have caused it to be relegated to the role of a rough measurement at best.

Another frequently used method which has been recently reinvestigated [2] is the oxidation of these end-groups by hypoiodite solutions. It is claimed that the reaction will give a good estimation under rigidly controlled experimental conditions. The method was checked by comparing it with viscosity measurements and with the results of titrations with silver *ortho*-nitrophenolate of the carboxyl groups formed by oxidation.

This method, like the copper-number method, has been open to many criticisms. As reported in Part

TABLE Ib. REACTION OF RAYON WITH POTASSIUM PERMANGANATE AT 0°C

Reagents: 0.0662*N* potassium permanganate
0.0843*N* sodium oxalate
0.25*N* sulfuric acid

Sample No.	Length of reaction (min.)	Weight of sample (g.)	Total volume $KMnO_4$ added (ml.)	Volume $Na_2C_2O_4$ added (ml.)	Milli-equivalents $KMnO_4$	Milli-equivalents $Na_2C_2O_4$	Milli-equivalents oxygen used up	Milli-equivalents oxygen used per g. rayon
	—	—	31.97	25.10	2.116	2.116	0.000	—
1	2.0	1.010	32.34	25.07	2.134	2.113	0.021	0.021
2	3.5	0.826	32.02	25.00	2.120	2.108	0.012	0.015
3	4.5	1.670	32.80	25.08	2.171	2.114	0.057	0.034
4	6.0	1.100	32.30	24.75	2.138	2.086	0.052	0.047
5	7.5	1.336	31.98	24.31	2.117	2.049	0.068	0.051
6	9.0	0.774	32.10	24.74	2.125	2.086	0.039	0.050
7	11.0	1.116	32.88	25.13	2.177	2.118	0.059	0.053
8	16.0	0.899	32.32	24.84	2.140	2.094	0.046	0.051
9	19.5	1.329	32.18	24.53	2.130	2.068	0.062	0.047
10	31.0	1.885	32.77	24.40	2.170	2.057	0.113	0.060
11	44.0	1.132	32.78	24.77	2.170	2.087	0.083	0.073
12	60.0	1.268	33.00	24.74	2.185	2.086	0.099	0.078
13	71.0	0.885	32.64	24.74	2.161	2.086	0.075	0.085
14	98.0	1.386	33.21	24.64	2.199	2.077	0.122	0.088
15	133.0	1.175	32.64	24.20	2.161	2.040	0.121	0.103

TABLE II. RAYON SAMPLES PRETREATED WITH POTASSIUM PERMANGANATE. REACTION WITH POTASSIUM PERMANGANATE AT 0°C

Reagents: 0.0733*N* potassium permanganate
0.0857*N* sodium oxalate
0.25*N* sulfuric acid

Sample No.	Length of reaction (min.)	Weight of sample (g.)	Total volume $KMnO_4$ added (ml.)	Volume $Na_2C_2O_4$ added (ml.)	Milli-equivalents $KMnO_4$	Milli-equivalents $Na_2C_2O_4$	Milli-equivalents oxygen used up	Milli-equivalents oxygen used per g. rayon
	—	—	30.05	25.69	2.203	2.202	0.001	—
1	3.0	1.020	29.26	24.88	2.145	2.132	0.013	0.013
2	6.5	1.678	29.30	24.95	2.147	2.138	0.009	0.005
3	11.5	1.503	30.17	25.65	2.210	2.198	0.012	0.008
4	17.0	1.561	29.84	25.29	2.187	2.167	0.020	0.013
5	21.0	1.114	29.91	25.42	2.192	2.179	0.013	0.012
6	26.0	0.976	30.05	25.50	2.203	2.185	0.018	0.019
7	31.0	0.919	29.67	25.16	2.175	2.156	0.019	0.021
8	43.0	1.047	28.87	24.51	2.116	2.101	0.015	0.014
9	61.0	1.267	29.55	24.95	2.166	2.138	0.028	0.022
10	88.0	1.459	30.14	25.34	2.209	2.171	0.038	0.026
11	104.0	1.246	29.35	24.76	2.151	2.122	0.029	0.023
12	126.0	1.563	30.33	25.38	2.223	2.175	0.048	0.031

II of this series [3], an investigation of its applicability for measuring aldehyde groups in periodate oxidized cellulose has demonstrated its inaccuracy. It was found that the oxidizing agent itself was unstable and that slight modifications in the procedure caused widely divergent results.

Another criticism of these methods arises from the fact that alkaline reagents are used. It has been claimed [4] that air oxidizes the terminal groups in the presence of alkali, thus starting a degradation of the chain.

The methods which depend on the formation of condensation products with the aldehyde groups include the use of the following reagents: phenylhydrazine [5], phenylhydrazine acetate [6], ethyl mercaptan [7], hydroxylamine hydrochloride [8], and other agents. For the majority of these reactions, the problems of inaccuracy and incompleteness of reaction exist. For most, accuracy within 5 to 10 percent is the best that can be claimed.

B. Development of a New Method of Estimation

It seemed necessary, therefore, to develop a new procedure which would embrace the following features: (*a*) the reaction would occur in acid medium; (*b*) it would be selective and quantitative; and (*c*) it would take place rapidly so that acid degradation of the cellulose would not occur during the estimation.

Potassium permanganate was found to be suitable for this purpose. It is well known that this reagent rapidly attacks cellulose in alkaline medium, giving rise to an "oxycellulose." However, our experiments showed that this attack was more selective in acid solution and apparently restricted itself to oxidation of the reducing groups.

For carrying out the preliminary tests, viscose rayon yarn was selected as a suitable material. The rayon was scrubbed with soap solution to remove finishing agents. It was thoroughly washed with distilled water, then dried in an oven at 50°C, and for three days in an evacuated desiccator over phosphorus pentoxide. This was adopted as a standard drying procedure for all experiments.

Samples of approximately one gram were allowed to react with acid solutions of potassium permanganate, each sample for a given time interval. Two series of experiments were carried out, one at 30°C

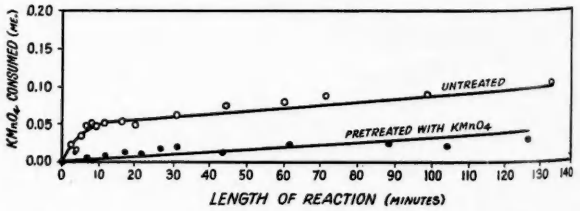


FIG. 2. *Milliequivalents of potassium permanganate consumed per gram of rayon at 0°C, testing for completeness of reaction.*

TABLE III. RAYON—REACTION AT 0°C WITH A SMALLER EXCESS OF POTASSIUM PERMANGANATE

Reagents: 0.1076*N* potassium permanganate
0.0585*N* ferrous ammonium sulfate
0.25*N* sulfuric acid

Sample No.	Length of reaction (min.)	Weight of sample (g.)	Total volume $KMnO_4$ added (ml.)	Volume $Fe(NH_4)_2(SO_4)_2$ added (ml.)	Milli-equivalents $KMnO_4$	Milli-equivalents $Fe(NH_4)_2(SO_4)_2$	Milli-equivalents oxygen used up	Milli-equivalents oxygen used per g. rayon
	—	—	7.65	14.07	0.823	0.823	0.000	—
1	3.0	1.107	7.67	13.86	0.825	0.811	0.014	0.013
2	5.5	1.321	7.70	13.73	0.829	0.803	0.026	0.020
3	9.0	0.988	7.68	13.62	0.826	0.797	0.029	0.029
4	14.0	1.044	7.86	13.59	0.846	0.795	0.051	0.049
5	22.0	1.234	7.77	12.95	0.836	0.758	0.078	0.063
6	34.0	1.000	7.90	13.31	0.850	0.779	0.071	0.071
7	49.0	0.893	7.85	13.30	0.845	0.778	0.067	0.075
8	68.0	0.986	7.85	13.11	0.845	0.770	0.075	0.076
9	94.0	1.320	8.01	13.03	0.861	0.762	0.099	0.075

and one at 0°C. For each sample, the treatment consisted of the following. The sample was placed in 100 ml. of 0.5*N* sulfuric acid solution, which had already been brought to the desired temperature. An exactly measured volume of standard potassium permanganate solution, which was greatly in excess of the amount necessary for the reaction, was run into a 500-ml. glass stoppered flask. Sufficient water was then added to make the total volume of the solution 100 ml. This flask was placed in the constant-temperature bath. After its content had reached the desired temperature, the rayon and acid were rapidly added from the other vessel. The reaction was allowed to proceed for the desired time interval, after which the reaction was terminated by the addition of a measured excess of standard sodium oxalate solution to the reaction mixture. The end-point was determined by back-titration with the standard potassium permanganate solution. From the total amounts of potassium permanganate and sodium oxalate, the milliequivalents of oxygen used up per gram of rayon were calculated. These values were plotted against the length of time the reaction proceeded. The results of the experiments at 30°C and at 0°C are listed in Table I and shown in Figure 1.

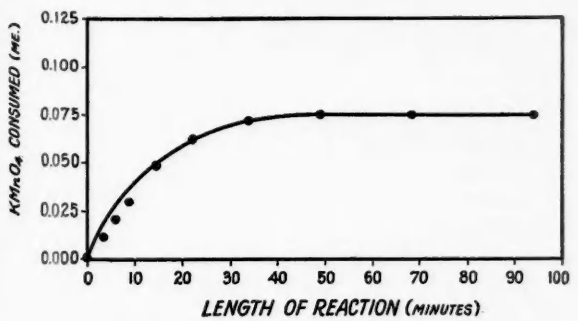


FIG. 3. *Milliequivalents of potassium permanganate consumed per gram of rayon.*

The latter shows that: (*a*) there is an initial rapid rate of consumption of reagent followed by a slower rate; (*b*) the slower rate is repressed by lowering the temperature, which fact is a desirable indication if this part of the curve is to be interpreted as being due to various side reactions; (*c*) the initial reaction is over in a short time; and (*d*) the heights of the breaks in the curves are approximately of the right order of magnitude.

It was then deemed necessary to establish by further experiments whether or not the rapid initial consumption of oxygen would take place in a second treatment of the same sample—that is, to ascertain first whether the reaction was essentially complete, and, second, to determine whether the side reactions could be eliminated by decreasing the large excess of potassium permanganate.

Both these experiments were carried out at 0°C. Rayon samples were prepared as before. One set of samples was steeped in acid permanganate solutions for 30 minutes at 0°C, washed, and dried. These were then submitted to the same experiment as described above. Second, a set of untreated samples was run in solutions of potassium permanganate of approximately one-third the concentration previously used, the experiment otherwise being the same.

TABLE IV. D.P.'s OF SEVERAL TYPES OF CELLULOSE

A. Viscose rayon
Reagents: 0.1076*N* potassium permanganate
0.0585*N* ferrous ammonium sulfate
0.25*N* sulfuric acid

Sample No.	Length of reaction (min.)	Weight of sample (g.)	Total volume $KMnO_4$ added (ml.)	Volume $Fe(NH_4)_2(SO_4)_2$ added (ml.)	Milli-equivalents $KMnO_4$	Milli-equivalents $Fe(NH_4)_2(SO_4)_2$	Milli-equivalents oxygen used up	Milli-equivalents oxygen used up per g. cellulose
	—	—	7.97	14.70	0.858	0.858	0.000	—
1	10	1.000	7.68	13.18	0.826	0.771	0.055	0.055
2	20	1.000	7.67	13.01	0.825	0.761	0.064	0.064
3	40	1.000	7.72	12.91	0.831	0.755	0.076	0.076
4	60	1.000	7.97	13.38	0.858	0.783	0.075	0.075
5	100	1.000	8.15	13.69	0.877	0.801	0.076	0.076

B. Surgical cotton
Reagents: 0.0803*N* potassium permanganate
0.0544*N* ferrous ammonium sulfate
0.25*N* sulfuric acid

	—	—	8.85	13.09	0.711	0.712	0.001	—
1	12	1.000	8.90	12.75	0.715	0.694	0.021	0.021
2	25	1.244	8.92	12.30	0.716	0.669	0.047	0.038
3	38	0.923	8.87	12.34	0.712	0.671	0.041	0.044
4	57	1.171	9.27	12.75	0.744	0.694	0.050	0.043
5	80	0.891	9.08	12.70	0.729	0.691	0.038	0.043

C. Pulp used for manufacture of viscose rayon
Reagents: 0.1076*N* potassium permanganate
0.0585*N* ferrous ammonium sulfate
0.25*N* sulfuric acid

	—	—	7.72	14.19	0.831	0.830	0.001	—
1	13	10.000	7.71	13.77	0.830	0.807	0.023	0.0023
2	22	10.000	7.84	13.38	0.844	0.783	0.061	0.0061
3	45	10.000	8.02	13.47	0.863	0.788	0.075	0.0075
4	68	10.000	8.08	13.58	0.869	0.795	0.074	0.0074
5	92	10.000	8.00	13.40	0.861	0.784	0.077	0.0077

Summary:

	Milliequivalents oxygen used per g. cellulose	Average D.P.	Average molecular weight
Viscose rayon	0.075	165	26,800
Cotton	0.043	290	47,000
Rayon stock	0.0075	1650	268,000

The results are shown in Tables II and III and in Figures 2 and 3.

Figure 2 shows the behavior of the pretreated samples as compared to that of untreated samples (values from Table Ib). The initial reaction no longer occurs, so it can be safely concluded that the initial reaction has indeed gone to completion. The slope that does exist parallels the final slope of the untreated samples, so this is evidently due to side reactions also.

It is seen in Figure 3 that decreasing the excess of potassium permanganate apparently eliminates these side reactions completely.

At this time it was found that ferrous ammonium sulfate was superior to sodium oxalate for the titrations, since it is sometimes troublesome to get the sodium oxalate to react at the temperatures employed.

Independent methods of checking this reducing-group estimation were needed. A procedure for the measurement of the carboxyl groups formed will be presented in detail in the next paper of this series. It should be mentioned here, however, that the two methods checked very well, apparently showing that overoxidation does not occur to an appreciable extent under these experimental conditions. Viscosity measurements and other physico-chemical means

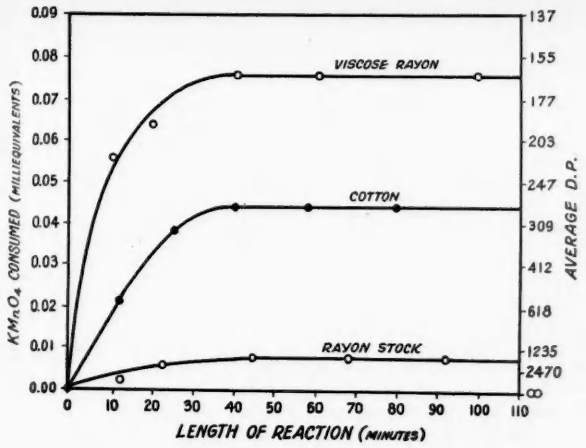


FIG. 4. *D.P.'s of three typical celluloses.*

have often been used for independent checks. The discussion of viscosity will also be deferred for the present.

C. A Standard Procedure

The following experimental method was finally adopted as standard for solid samples.

Weigh out five 1-gram samples of the cellulose under investigation. Measure into each of five 500-ml. glass stoppered flasks a standard excess of potassium permanganate solution. We employed an amount approximately equivalent to ten times the amount required for the reaction—i.e., 7 ml. of 0.1*N* potassium permanganate. Dilute to 100 ml. with distilled water. Cool to 0°C in an ice bath. Add each of the cellulose samples to 100 ml. of 0.5*N* sulfuric acid which has been previously cooled to 0°C and pour each of these mixtures into one of the permanganate solutions. Let each react for a different time interval and then terminate the reaction by adding a measured excess of ferrous ammonium sulfate solution. Back-titrate to the end-point with potassium permanganate. Plot milliequivalents of oxygen used up per gram of cellulose against length of time of reaction. The height of the level part of the curve gives the measure of the reducing power of the material. If this be all reducing end-groups, the average degree of polymerization can be calculated from the formula:

$$\text{D.P.} = 12.35/x,$$

where x is the milliequivalents of oxygen used up per gram of cellulose.

D. D.P.'s for Typical Celluloses

The degrees of polymerization of the following materials were then determined by the procedure outlined above: (*a*) viscose rayon, (*b*) surgical cotton, and (*c*) cotton pulp used for rayon manufacture. Table IV and Figure 4 give the results of these estimations.

Summary

Potassium permanganate was found to be a suitable reagent for the estimation of reducing end-groups in cellulose. The procedure employs the use of dilute potassium permanganate in sulfuric acid medium at 0°C.

The reaction was found to be selective and complete. The values obtained were reproducible. Reasonable degrees of polymerization were obtained for typical cellulosic materials.

Literature Cited

1. Schwalbe, *Ber. Deutsch. Chem. Ges.* **40**, 1347 (1907).
2. Martin, Smith, Whistler, and Harris, *J. Research Natl. Bur. Standards* **27**, 449 (1941).
3. Pacsu, TEXTILE RESEARCH JOURNAL **16**, 105 (1946).
4. Nakashima, *J. Soc. Chem. Ind. Japan* (Suppl.) **34**, 422 (1931).
5. Bergmann and Machemer, *Ber. Deutsch. Chem. Ges.* **63**, 316 (1930).
6. Staud and Gray, *Ind. Eng. Chem., Anal. Ed.* **1**, 80 (1929).
7. Wolfrom and coworkers, *J. Am. Chem. Soc.* **59**, 282 (1937); **60**, 1026 (1938); **60**, 3009 (1938); and **61**, 1072 (1939).
8. Gladding and Purves, *Paper Trade J.* **116**, 261 (1943).

Study of Chemical Degradation of Cellulose in Cotton Tire Cords as a Result of Road Service and Wheel Testing Carried to Failure

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Summary

In order to determine whether, and to what extent, chemical degradation occurs in the cellulose of cotton tire cords "in service," cuprammonium fluidity measurements have been made on cords taken from 7.50–20 tires operated to failure on the Normoyle, Texas, road course, and on a National Bureau of Standards "wheel." For comparison, the fluidity was also determined on cords taken from control tires which were identical in construction. In one test, measurements were also made upon the cotton before processing. Special techniques were required to remove adhering rubber particles from the cuprammonium dispersions before measurements.

The results showed that the chemical degradation caused by operation to failure was, in general, of a minor degree—in some cases, even undetectable after long operation. Degradation increased with the increase in percent of normal load on the tires during road operation. Tires operated on the "wheel" showed considerably greater degradation than those operated on the road course. Appreciable degradation of the cellulose occurred during the manufacture of the tires, presumably during drying, calendering, and vulcanization.

While there were differences in gage of cord used in the tires and differences in climatic conditions during operation on the road, the test used was not one which could distinguish any differences in degradation from these sources.

Tests of Chemical Degradation of Tire Cords

The final failure of tires is ordinarily associated with the failure of the supporting structure—that is, the cord—and while it is probable that the immediate cause of failure is the disturbance of the load distribution and the concentration of the load in localized areas, there is also the possibility that cord failure is due to deterioration from overheating or other chemically degradative action. Truck tires in many types of heavy-duty service become hot and frequently attain equilibrium running temperatures of 250°F and even higher in certain regions of the tire body. Operating temperatures higher than 275°F are usually signals of impending failure. It is conceivable, furthermore, that continual flexing could result in chemical degradation, irrespective of the action of heat.

A number of investigators, including Truesdale [10], Fuwa [2], Knecht and Muller [5], Tiltman and Porritt [9], and Haas [4], have studied the effect of heat on cotton. Permanent loss of strength of cotton in the air has been noted at temperatures as low as 194°F. It seems to be well established that permanent loss of strength, detectable in as little as 4 hours, begins first at about 248°F in the air or at 285°F *in vacuo*. Tests for cellulose decomposition have shown a significant change in the air below 212°F and quite marked change at 285°F. It will be noted that these temperatures cover a considerable range and one which may be expected frequently in the ordinary long-distance operation of tires on the road.

Cuprammonium fluidity measurements provide a sensitive test for the detection of incipient chemical degradation of cellulose, and the relative degree of polymerization of the cellulose may be estimated from such measurements. It was the purpose of the experiments reported here to determine, if possible, whether, and to what extent, chemical degradation occurred in the cord under certain conditions of road- and wheel-testing of the tires.

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Experiments to determine chemical degradation were carried out on the cords from two sets of tires of size 7.50–20, manufactured by a commercial tire company with 90 percent GR-S rubber and cord from singles yarns spun at the Southern Regional Research Laboratory. In the cords from the first series of tires (see below), all other steps in the processing were done by a commercial cotton mill. The cords for the second series of tires were manufactured and stretched by the Southern Regional Research Laboratory and only woven by a commercial cotton mill. Both sets included representative tires tested under actual road-service conditions, as well as undamaged control tires. One of the sets included tires run in the National Bureau of Standards "wheel" test, which is carried out indoors at a temperature of about 100°F and simulates road testing in some respects. Differences in the construction and operation of the tires and selection of the test cords for the two series were as follows:

First Series of Tires

The cords of the first set of tires were of low-gage (23/4/3) construction. The failed tires had been run in road test N-285 at Camp Normoyle, Texas, by the tire-testing fleet of the Army Ordnance Department [7]. The tires, inflated to 55 p.s.i. cold, were run on 2½-ton trucks at a maximum permissible speed on the highway of 45 miles per hour, over a course which was approximately 15 percent cross-country, 15 percent gravel roads, and 70 percent hard roads. About one-third of the time the average speed was 12 miles per hour, for the cross-country portion of the course. Based on a normal load of 2,250 pounds per tire for tires of this size, the center and rear tires were run at 63 percent of the normal load (1,410 pounds), while the front tires were run at 118 percent of the normal load (2,650 pounds). The tire of this series made with SxP cotton was run on the rear outside; that made with Stoneville 2B cotton, on the center outside; and the one made with Wilds 13 cotton, on the center inside. Thus, all of the tires were run at 63 percent of rated load. Since this road test was carried out during the fall and winter months, the running temperatures of the tires were comparatively low. All cords used in this series were taken from the second ply, counting from the inside of the tire. As controls, cords from comparable tires of the same set were selected from those used for penetration tests at the National Bureau of Standards. Data obtained from this series of cords, according to the procedure described below, are presented in Table I and are discussed later in this paper.

Second Series of Tires

Cords of medium-gage construction (17/4/3 and 16/4/3) from a second series of tires were investigated. These tires, some made from Wilds 13 cotton from the two crop years 1942 and 1943 and some from the manufacturer's "regular" cotton, were run to failure in the Camp Normoyle road test N-395; others were tested on the "wheel" at the National Bureau of Standards. Representative tires which had been subjected to the penetration, or "plunger," test were employed as controls, which, except for the road or wheel operation, had been subjected to identical conditions.

The road test on the second series was conducted at Camp Normoyle during the summer months, and the running temperatures were moderately high. Other conditions duplicated those of the road test of the first series.

In the National Bureau of Standards "wheel" test, the tires were mounted on a wheel, inflated to a pressure of 55 p.s.i. cold, loaded, and operated on a smooth drum at a speed of 30 miles per hour. During operation the pressure inside the tires increased to 60 to 63 p.s.i., owing to increased temperature. The starting load of 1,800 pounds (80 percent of normal load) was increased to 2,250 pounds (100 percent) after running 720 miles and to 2,700 pounds (120 percent) after running 1,440 miles. Thereafter, the load was increased 225 pounds, or 10 percent, for each additional 720 miles' run until failure occurred. Based on temperature readings in other similar tires, the range of temperatures in these tires was from 250 to 280°F. In this series, the cord samples were taken from the seventh ply, instead of the second, counting from the inside of the tire. Data obtained from this series, also according to the analytical procedure described immediately following, are presented in Table II and discussed in conjunction with the corresponding data for the first series of tires.

Analytical Procedure

For the chemical analysis and fluidity measurements about 10 grams of cord were removed from each tire in such a way as to avoid as much of the rubber as possible. The cords were extracted with hot ethyl alcohol in a Soxhlet apparatus for 4 hours, washed out with water, and allowed to dry overnight

TABLE I. FLUIDITY AND DEGREE OF POLYMERIZATION OF THE CELLULOSE OF DIFFERENT COTTONS USED IN THE CORDS AND OF CORRESPONDING TIRE CORDS TAKEN FROM TIRES BEFORE TESTING AND AFTER FAILURE ON THE NORMOYLE TEST ROUTE, UNDER THE CONDITIONS INDICATED

Sample No.	Variety of cotton	Treatment of tire	% of normal load carried	Miles run	Fluidity of solution (rhes)	Computed D.P.
Original cotton	SxP				1.96 ± 0.07	2420
Co 1541	SxP	Control		0	3.24 ± 0.01	2020
Co 1540 R.O.	SxP	Road test	63	14,506	2.95 ± 0.05	2090
Original cotton	Stoneville 2B				2.07 ± 0.06	2375
Co 1544	Stoneville 2B	Control		0	3.18 ± 0.10	2030
Co 1543 C.O.	Stoneville 2B	Road test	63	9,720	3.30 ± 0.12	2005
Original cotton	Wilds 13 1942				1.91 ± 0.07	2435
Co 1542	Wilds 13 1942	Control		0	2.82 ± 0.05	2125
Co 1513 C.I.	Wilds 13 1942	Road test	63	17,809	2.90 ± 0.04	2105

in the air. The samples of cord were then ground to pass the 20-mesh screen of a semimicro Wiley mill.

Weighed portions of the samples were dissolved in cuprammonium solution to give concentrations of approximately 0.5 gram per 100 milliliters, based on the cellulose content of the samples. The cellulose content of each cord sample was determined by dissolving the cellulose in 72 percent sulfuric acid, filtering through a tared sintered glass crucible to remove the rubber particles, and oxidizing the filtrate with a measured amount of standard dichromate solution. From the volume of dichromate required, the cellulose present in the sample could be computed. It was found that the rubber particles, adhering to the cord, varied with the sample, amounting to from 6 to 15 percent of the sample weight. Parallel moisture determinations were made from which both a conversion to the dry basis could be made and a check provided on the amount of the combined rubber and cellulose determinations. The fluidity of the cuprammonium solutions was measured in a buret viscometer and adjusted to a velocity gradient of 500 sec^{-1} according to the technique of Conrad [1]. During preliminary measurements it was observed that many of the rubber particles present in the solution attached themselves to the capillary wall, and it was feared that they might thus affect the rate of discharge. Accordingly, a special technique was devised whereby the rubber particles were removed from the cuprammonium solution before the fluidity measurements were made.

In this special technique, the weighed cotton sample, containing the adhered rubber particles, was first dispersed in cuprammonium solution in a viscometer buret, rotating end over end, overnight. The dispersion was then transferred without exposure to the air through a tube to a 50-ml. closed centrifuge tube. This had previously been cleared of atmospheric oxygen, first by displacement with nitrogen and then by alternate evacuation and refilling with nitrogen through an outlet tube with stopcock. The dispersion was centrifuged for 3 hours, this period of time having been shown in separate experiments to be more than ample for separating the rubber particles and it having been found that the fluidity remained constant after one hour. The supernatant solution, free of rubber particles, was again transferred to a buret viscometer, brought to 25°C in a thermostat bath, and the time of discharge measured. It was also shown in separate experiments that neither the special technique employed nor the time of centrifuging used here had any effect on the fluidity values of a cotton sample containing no foreign matter, as compared with the usual method. The computed fluidity of each sample was adjusted to a concentration of 0.5 gram per 100 milliliters.

The degree of polymerization was computed from the ratio of the solvent and solution fluidities, using the Baker-Philippoff [8] formula to extrapolate to infinite dilution and Kraemer's [6] constant, 260, for the conversion of intrinsic viscosity to D.P. It is recognized in view of the work of Gralen and Sved-

TABLE II. FLUIDITY AND DEGREE OF POLYMERIZATION OF THE CELLULOSE FROM COTTON TIRE CORDS BEFORE TESTING AND AFTER FAILURE ON THE NORMOYLE TEST ROUTE AND WHEEL TESTS AT THE NATIONAL BUREAU OF STANDARDS, UNDER THE CONDITIONS INDICATED

Sample No.	Variety of cotton	Treatment of tire	% of normal load carried	Miles run	Fluidity of solution (rhes)	Computed D.P.
Co 2591	Wilds 13 '42	Control		0	3.02 ± 0.01	2085
Co 2592	Wilds 13 '42	Road test	118	5,779	3.81 ± 0.02	1905
Co 2593	Wilds 13 '42	Road test	63	16,081	3.42 ± 0.06	1990
Co 2594	Wilds 13 '42	Wheel test	80–110	2,712	5.70 ± 0.15	1610
Co 2584	Wilds 13 '43	Control		0	2.87 ± 0.05	2125
Co 2585	Wilds 13 '43	Road test	118	6,036	3.92 ± 0.05	1885
Co 2586	Wilds 13 '43	Road test	63	16,352	2.96 ± 0.02	2100
Co 2587	Wilds 13 '43	Wheel test	80–110	2,594	5.15 ± 0.10	1685
Co 2588	"Regular"	Control		0	3.42 ± 0.10	1990
Co 2589	"Regular"	Road test	118	5,255	4.00 ± 0.05	1870
Co 2590	"Regular"	Wheel test	80–100	1,928	4.70 ± 0.02	1750

berg [3] that the computed degree of polymerization is indicative only of the relative magnitude of the D.P.'s and not of their absolute values.

Results and Conclusions

The results obtained on the low-gage cords from Normoyle Test N-285 and the control cords are shown in Table I, which also includes data on the original cottons from which the cords were constructed. The fluidity values on the original cottons were obtained without centrifuging their solutions. The results of Normoyle Test N-395 on medium-gage cord are presented in Table II.

It will be observed from Table I that the fluidity of the cellulose from the low-gage cords, taken from the first series of tires, was considerably higher than that of the original cottons, in the case of the controls as well as of the road-tested samples. This may be ascribed, probably, to the decomposition associated with heating of the cotton in the cords during drying, calendering into the rubber, and vulcanization into the tire. During the last operation, the temperature reaches approximately 290°F. The cellulose of the cords from the road-tested tires shows little difference in fluidity from that of the control cords. In one case, the fluidity of a control cord was slightly greater than that of a road-tested cord. However, it is believed that the small differences in fluidity between the control and the tested samples are within the limits of experimental error. The computed D.P.'s corresponding to the fluidities are shown in the last column.

In Table II, the fluidity of the cellulose of cords from operated tires is seen to be, in all cases, higher than that of the cords from the control tires. In most cases the differences may be considered to be statistically significant. One observes that the degradation produced in the wheel test exceeds that produced by the road test, which indicates that conditions contributing to the chemical damage of the cotton were more severe in the wheel test. A comparison of the data on cords run overloaded with those of cords run underloaded in the road test shows greater degradation from the overloading, as might be expected. Given in this table also, for comparative purposes, are the D.P.'s corresponding to the fluidity values.

The trend of the data with respect to treatment is similar in both low- and medium-gage cords, in so far as the data are comparable. No significant difference can be seen in similarly tested cords in so far as climatic conditions during test are concerned.

In none of the samples upon which measurements have been made has more than minor chemical degradation been detected. The results do not supply any evidence that the failure of tire cords generally should be ascribed to this type of deterioration.

Literature Cited

1. Conrad, Carl M., Role of velocity gradient in determining the cuprammonium fluidity of cellulose. *Ind. Eng. Chem., Anal. Ed.* **13**, 526–33 (1941).
2. Fuwa, T., Some tensile properties of cotton yarn. *Textile World* **64**, 3577, 3579, 3581 (Dec. 15, 1923).

3. Gralen, N., and Svedberg, The, The molecular weight of native cellulose. *Nature* **152**, 625 (1943).
4. Haas, Heinz, Beiträge zur Kenntnis der Einwirkung der Wärme auf die Baumvolle. Dissertation, Würzburg, June, 1935.
5. Knecht, E., and Muller, E. F., Some further notes on the action of heat on cotton cellulose. *J. Soc. Dyers and Colourists* **41**, 43–7 (Feb. 1925).
6. Kraemer, E., Molecular weights of cellulose and cellulose derivatives. *Ind. Eng. Chem.* **30**, 1200–3 (1938).
7. Lemon, B. J., and Robson, J. J., Ordnance keeps 'em rolling. *India Rubber World* **109**(**5**), 463–7 472 (1944).
8. Philippoff, W., Die Bedeutung der Viscosität für die Chemie der Cellulose. *Cellulosechem.* 17, 57–77 (1936).
9. Tiltman, A. H., and Porritt, B. D., The effect of heat on cotton. Initial changes in tensile strength of unproofed fabric. *India Rubber J.* **76**, 245–8 (1928).
10. Truesdale, R. A., The influence of heat on physical properties of yarns. *Textile Recorder* **40** (472), 52–4 (Aug. 15, 1922).

Mechanical Properties of Textiles, VII*

The Visco-Elastic Properties of a Wool Fiber

George Halsey † and Henry Eyring ‡

Contribution of The Textile Foundation and the Textile Research Institute Laboratories, Princeton University, Princeton, New Jersey

INSTEAD of presenting many simple experiments on many different wool fibers, this paper gives the analysis of a single, complex experiment. The objects of the investigation were to answer the two questions: "What is the molecular property of wool that results in its peculiar recovery power?"; "If in wool there is a transformation induced by stretching and not in cellulose, why does the wool stress-strain diagram not show 'additional features' dependent on this transformation?"

From a broad point of view, the answer to the latter question is: "If a material has been competitively selected for a textile fiber, it necessarily possesses certain properties, including a stress-strain diagram similar to that of any other fiber." The query "Why, then, are two of these similar processes not discovered in a fiber, where the opportunity presents itself?" is not to be denied, but the general observation can be made that, if several competing processes seem qualitatively available, usually a single one will be easiest by far to the palpable exclusion of the others.

A more specific answer is that, considered microscopically, each process of relaxation in cellulose is quite similar to that in wool, except that in cellulose not so much elongation is available and a stronger force is employed. The fact that in cellulose this process is never regular enough to be discovered by x-ray analysis does not disallow its essential similarity to the process in wool. It has been proposed [1], to account for the behavior of wool protein as a subject of x-ray diffraction, that the protein molecule exists in an α and a β modification. The α modification, which is found in the unstretched fiber, is characterized by a folded tongue-and-groove structure capable of a great elongation. Upon elongation a transformation in the x-ray properties occurs, leading to the characterizing of a β form of a zigzag structure. This transformation is said to be reversible—that is, upon the relaxation of form β, form α is reproduced.

There are two extremes of behavior possible for a transformation of this type: it can be perfectly reversible in the sense that no dissipation of energy occurs or it can be completely dissipative. These two extremes correspond to a spring and to a dashpot, respectively.

Neglecting for the moment the mechanism whereby it could be effected, the stress-strain curve of a single elongation of a wool fiber could be explained on the basis of a single (if peculiar) spring alone. This spring would have to be approximately Hookean in the early range of extension. At the point corresponding to the yield point, the curve flattens out, because the transformation discussed above is considered to take place here, at approximately constant force. Beyond this transformation the stress-strain curve again turns upward

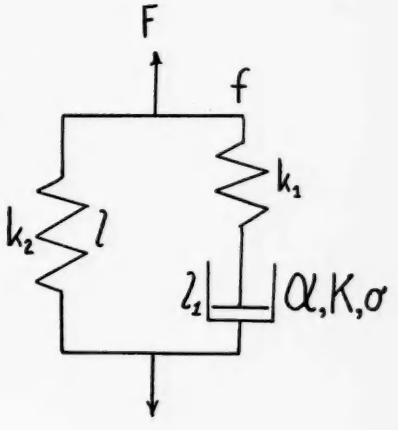

FIG. 1. *The three-element model with unsymmetrical potential barrier and non-Hookean spring used in this paper to represent wool.*

* This is the seventh paper in a series, "Mechanical Properties of Textiles." The previous papers were published in the September and December, 1945, and the January, February, March, and May, 1946, issues. Paper VII was originally presented before the Division of Physical and Inorganic Chemistry at the Atlantic City meeting of the American Chemical Society, April 8–12, 1946. Paper VIII follows, on page 335.

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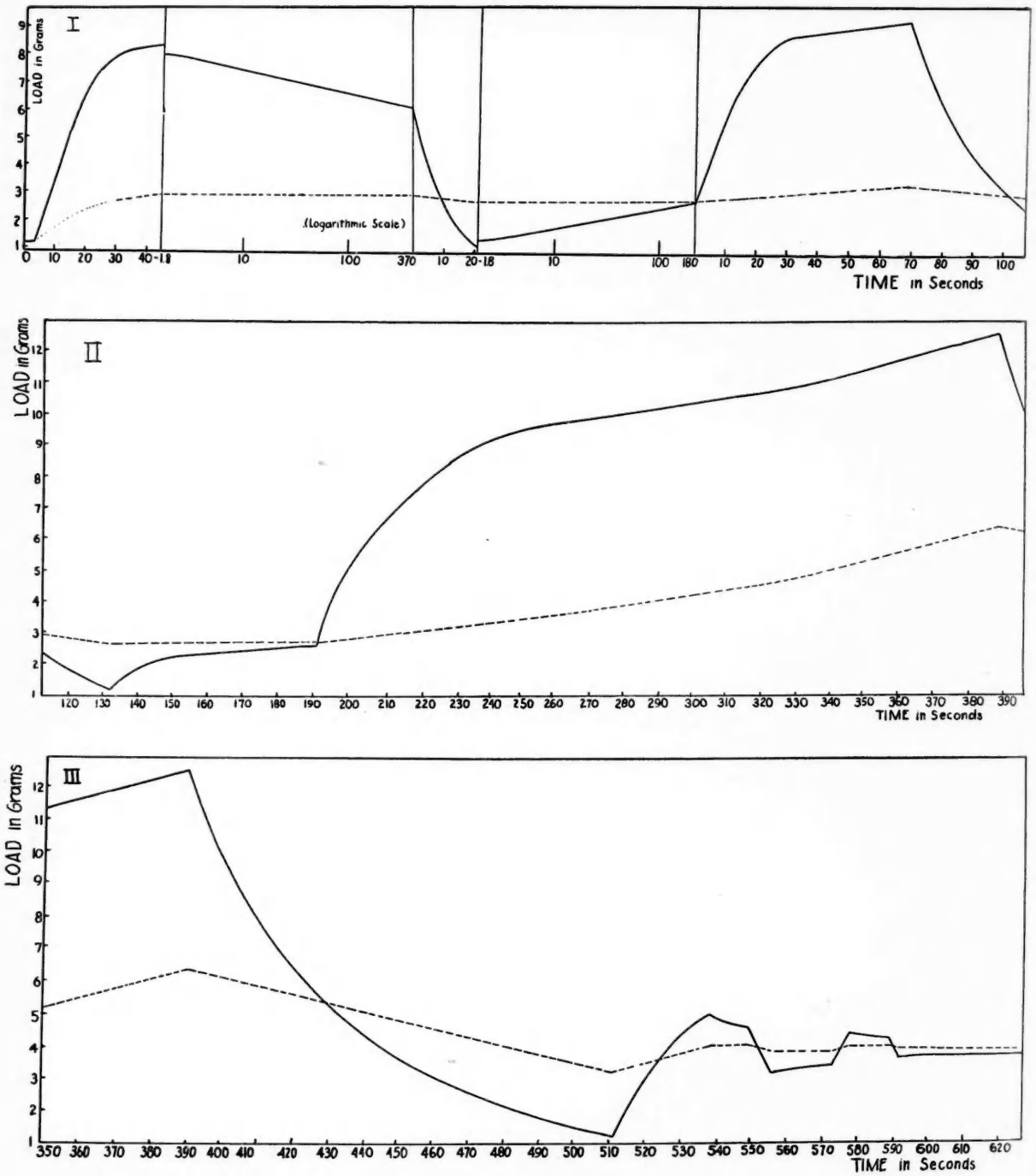
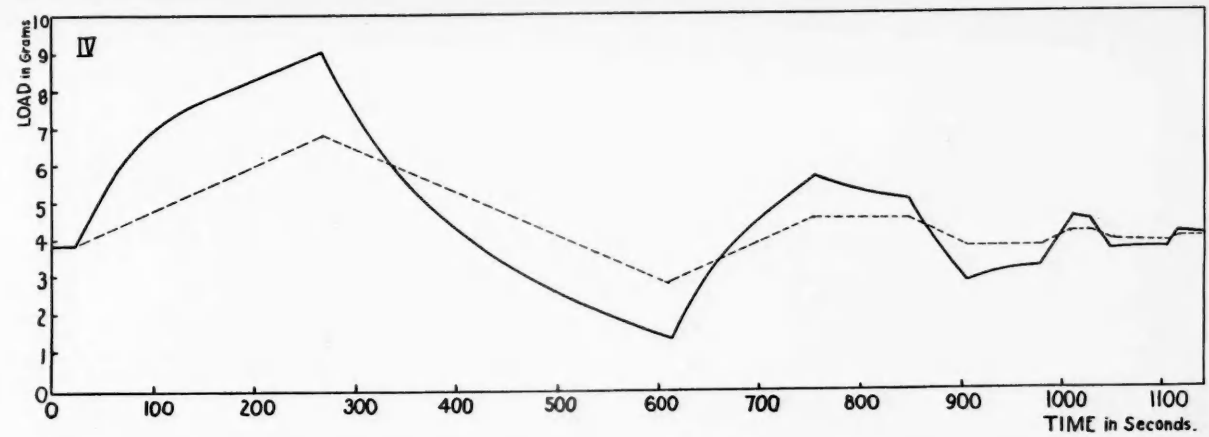


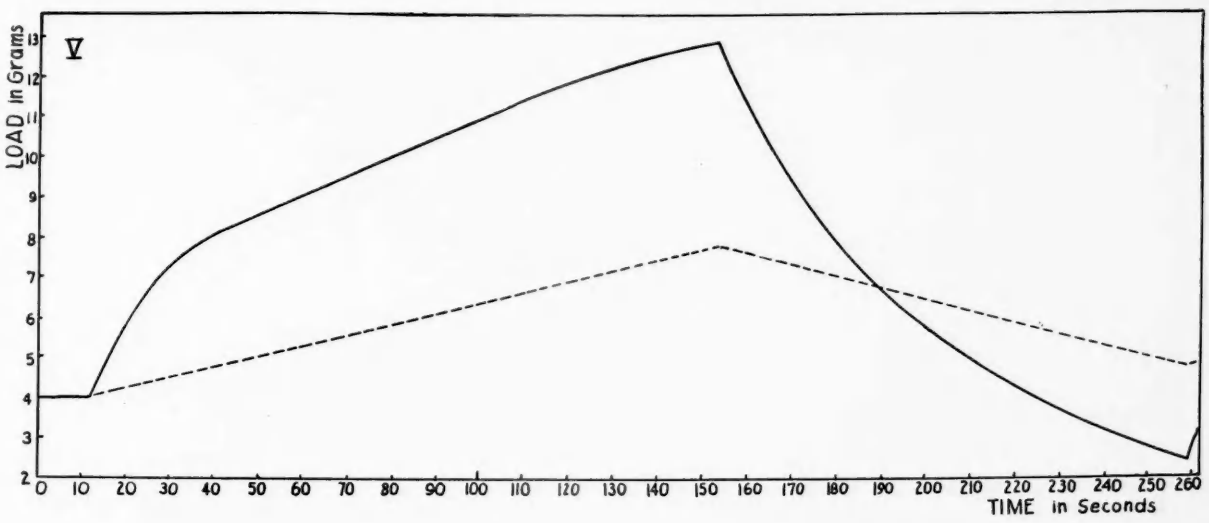
FIG. 2 (I–VI). *A complicated experiment performed on a 48s sound wool fiber.*

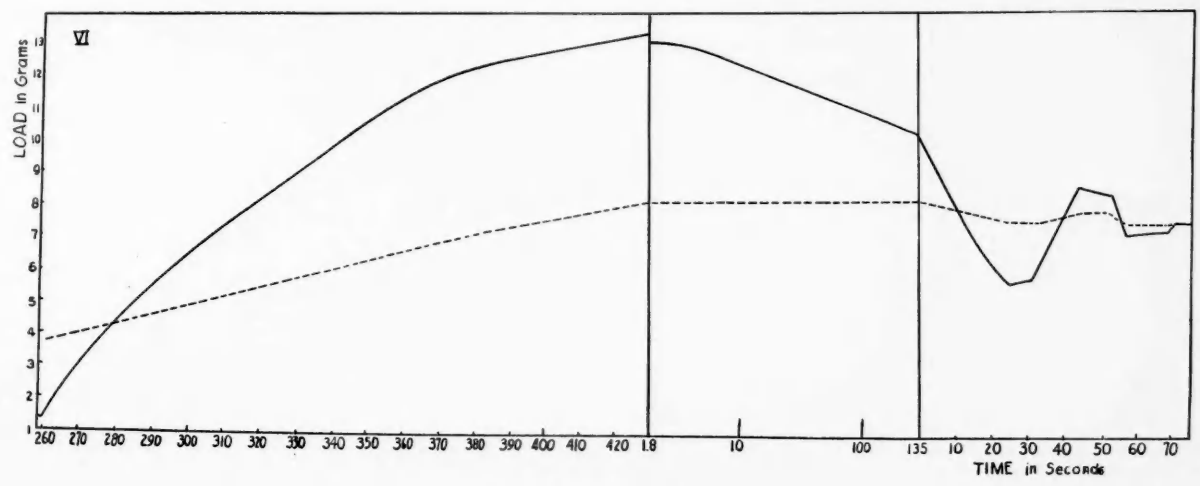
because the extreme length of the molecules is being attained in this region. A characteristic of this system is the absence of hysteresis associated with the transformation. Thus, a contraction of the fiber would lead to a stress-strain curve which would be a mirror image of the original curve.

Conversely, if the transformation proceeded with complete dissipation when such a transformation occurred, it would be possible to represent the first elongation with a dashpot coupled with a spring that was approximately Hookean.

At a certain yield point the (non-Newtonian)







dashpot would begin to yield, producing an effect entirely similar to the single non-Hookean spring. However, upon reversing the elongation and unloading the fiber, an entirely different effect would be noticed. The force would decay very sharply (as analyzed in preceding papers) and a permanent set, corresponding to a permanent transformation, would be observed.

Now, upon examining a typical stress-strain curve for wool (Figure 2) it is apparent that dissipation is certainly present, and thus the explanation of the single non-Hookean spring cannot be used.

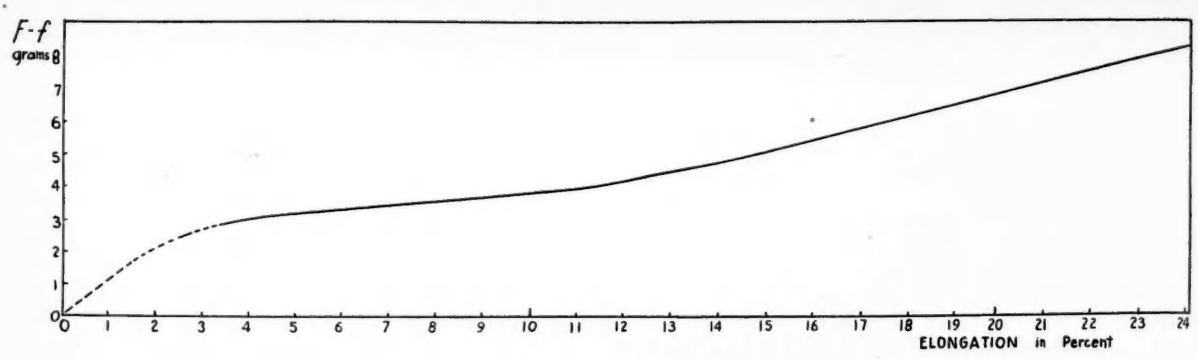


FIG. 3. *The non-Hookean spring used in the model (Figure 1) to represent wool.*

On the other hand, some elastic component is obviously present, because the transformation is recoverable, which is not provided for by the second extreme. The presence of this elastic component can be recognized in Figure 2. Therefore, as might be expected, it is necessary to use a more complex intermediate model, which corresponds to the three-element model of earlier papers in this series (Figure 1).

In Figure 2 the complex stress-strain curve is analyzed into F–f, the force on the pure spring, and f, the force on the dashpot, by the methods of the authors' previous papers [2].

The conception of the transformation of wool upon stretching as a purely springlike reaction is valid in the limited sense when the stress-strain curve is analyzed and the over-all force, F, is replaced by the force, F–f, on the pure spring k_2, of the model, Figure 1. This spring is shown in Figure 3. Qualitatively, it resembles the stress-strain curve of a wool fiber. Conceptually, it represents the result of an infinitely slow experiment under the ideal assumption that no new yielding mechanisms were discovered. This, of course, would not be realizable.

When the force on the dashpot, f, is considered, the most important fact about wool is discovered, and the first question raised in this paper, concerning superior recovery power, is answered. It is apparent from Figure 2, part III, that the force necessary to move the dashpot out is several times that required to move it back.

If the viscous law is

$$\frac{dl}{dt} = K \sinh \alpha f,$$

it is apparent that the force required to move the dashpot forward at a rate ρ is determined by

$$\rho = K \sinh \alpha f_{\text{out}}.$$

Likewise, the force backward is determined by $-\rho = K \sinh \alpha f_{\text{in}}$, whence

$$f_{\text{out}} = -f_{\text{in}}.$$

It is to be remembered that in the derivation of the sinh law the assumption was made that the potential barrier was symmetrical, making the general law

$$\frac{dl_1}{dt} = \frac{K}{2}\left(e^{+2\mu\alpha f} - e^{-2(1-\mu)\alpha f}\right)$$

take the form

$$\frac{dl}{dt} = K \sinh \alpha f,$$

with the special value $\mu = \frac{1}{2}$ assumed. When μ is not one-half,

$$f_{\text{out}} \neq -f_{\text{in}}.$$

In the case of rayon, this assumption of a symmetrical potential barrier is a suitable working hypothesis, although there is some evidence to the contrary.

However, in wool, it is glaringly not applicable. μ is approximately one-fourth. If there is any deviation in rayon, it is in the other direction—that is, rayon is of even poorer resilience than the symmetrical barrier would give.

Thus, the value of μ is extremely important with respect to resilience; it is essentially the resilience parameter, more important than the previously defined [2] $Q = k_2/k_1 + k_2$, which determines the force available to push the fiber back into place.

The Calculation of Constants

If an unsymmetrical potential barrier exists, then

$$\frac{dl_1}{dt} = \frac{K}{2}\left(e^{2\mu\alpha f} - e^{-2(1-\mu)\alpha f}\right),$$

where μ is the symmetry coefficient. Equivalent to this expression,

$$\frac{dl_1}{dt} = Ke^{-(2\mu-1)\alpha f} \sinh \alpha f.$$

If $2\mu - 1$ is defined as σ, the equations for the three-element model of Figure 1 become

$$\frac{dl_1}{dt} = Ke^{-\sigma\alpha f} \sinh \alpha f,$$

$$\begin{aligned} f &= k_1(l - l_1), \quad \text{and} \\ F - f &= k_2(l). \end{aligned}$$

These equations yield

$$\rho - \frac{1}{k_1}\frac{df}{dt} = Ke^{-\sigma\alpha f} \sinh \alpha f,$$

where

$$\rho \equiv \frac{dl}{dt}.$$

If

$$\beta \equiv \frac{\rho}{K},$$

$$\alpha f \equiv \varphi,$$

and

$$K\alpha k_1 t = \tau,$$

then

$$\beta - \frac{d\varphi}{d\tau} = e^{-\sigma\varphi} \sinh \varphi,$$

which yields

$$-\tau = \int \frac{d\varphi}{\beta + e^{-\sigma\varphi} \sinh \varphi},$$

which is not integrated. Therefore, it is not possible to determine the constants of the equations from the shape of the φ curve except in the simple case treated heretofore where $\sigma = 0$.

The measurement of the ratio

$$\left(\frac{f_n}{f_1}\right)_\infty = \left(\frac{\varphi_n}{\varphi_1}\right)_\infty$$

is available, however, to determine these constants.

Using the notation φ_1^{out} for the ultimate value of φ going forward at speed 1, and similarly φ_n^{out}, φ_1^{in} and φ_n^{in} for the other three ultimate values, the equations, when $\frac{d\varphi}{d\tau}$ becomes zero, are

$$\begin{aligned} \beta &= e^{-\sigma\varphi_1^{\text{out}}} \sinh \varphi_1^{\text{out}}, \\ n\beta &= e^{-\sigma\varphi_n^{\text{out}}} \sinh \varphi_n^{\text{out}}, \\ \beta &= e^{+\sigma\varphi_1^{\text{in}}} \sinh \varphi_n^{\text{in}}, \quad \text{and} \\ n\beta &= e^{+\sigma\varphi_n^{\text{in}}} \sinh \varphi_n^{\text{in}}. \end{aligned}$$

Using the approximation $\sinh x = e^x/2$ for large x, these equations become

$$\begin{aligned} \log 2\beta &= (1 - \sigma)\varphi_1^{\text{out}}, \\ \log 2\beta + \log n &= (1 - \sigma)\varphi_n^{\text{out}}, \\ \log 2\beta &= (1 + \sigma)\varphi_1^{\text{in}}, \quad \text{and} \\ \log 2\beta + \log n &= (1 + \sigma)\varphi_n^{\text{in}}. \end{aligned}$$

Or, dividing by the first and third of this set,

$$R^{\text{out}} = \frac{\log 2\beta + \log n}{\log 2\beta} = R^{\text{in}}$$

and

$$R_1 = \frac{1 + \sigma}{1 - \sigma} = R_n,$$

where

$$R^{\text{out}} = \left.\frac{f_n^{\text{out}}}{f_1^{\text{out}}}\right|_\infty,$$

$$R^{\text{in}} = \left.\frac{f_n^{\text{in}}}{f_1^{\text{in}}}\right|_\infty,$$

$$R_1 = \left.\frac{f_1^{\text{in}}}{f_1^{\text{out}}}\right|_\infty,$$

and

$$R_n = \left.\frac{f_n^{\text{in}}}{f_n^{\text{out}}}\right|_\infty.$$

From these equations for large φ,

$$\beta = \tfrac{1}{2}n^{1/R-1}$$

(as is found for this approximation when $\sigma = 0$) and

$$\sigma = \frac{R_1 - 1}{R_1 + 1},$$

or

$$\mu = \frac{R_1}{R_1 + 1}$$

or the corresponding formula with R_n, which is always more accurate. In the other approximation, when φ is small, the four equations become so simple that σ disappears completely in harmony with the necessary equality of the rates of reaction at equilibrium, satisfying the principle at detailed balancing.

As a second degree of approximation, consider that

$$\begin{aligned} \beta &= \beta_0 + \beta_1, \\ \sigma &= \sigma_0 + \sigma_1, \quad \text{and} \\ \varphi_1^{\text{out}} &= \varphi_0 + \varphi_1, \end{aligned}$$

where φ_0 is determined from the equation

$$\varphi_0 = (1 - \sigma_0) \log 2\beta.$$

Thus, this yields four equations to be solved simultaneously for the second approximation.

Application to a Specific Diagram

In Figure 2 the record of a complicated stress-strain diagram is presented. This experiment was performed using the methods of the preceding papers of this series.

Part IV was performed at a constant rate of elongation ρ, and at all other times the rate was 4ρ. Part III, as mentioned before, shows very clearly the presence of the unsymmetrical barrier. The two limiting forces have a ratio of almost three.

In part IV, when the rate is decreased fourfold, the ratio decreases in harmony with the principle of detailed balancing.

In parts V and VI, the original speed was resumed. The total value of the ratio was not regained, presumably because of disorganization brought about by the repeated stressing.

The non-Hookean spring used for the function $F - f = k_2(l)$ is presented in Figure 3. Because this is presumably separated from time-dependent processes it is the "characteristic" spring of the structure transformation of wool, and probably should be used to study this transformation in place of the raw stress-strain diagram of wool. The specific constants involved in the experiment follow:

The material was wool, 48s, sound.*
The diameter was taken to be 33 microns.

$$\rho = 0.000193$$
$$R_{out} = 2.65$$
$$R_{in} = 1.39$$
$$R^1 = 1.53$$
$$R^4 = 2.94$$
$$\beta = 4.7$$
$$\alpha = 2.17 \times 10^{-8}$$
$$K = 4.1 \times 10^{-5}$$

in c.g.s. units.

The free energy of activation, $\Delta F^{\ddagger}$, was calculated to be 23,100 calories. The size of the hole into which the flowing segment moves was calculated to be 11.9 Å. cubed.

Literature Cited

1. Astbury, W. T., in Alexander's "Colloid Chemistry," Vol. V. New York, Reinhold Publishing Corp., 1945.
2. Halsey, George, White, Howard J., Jr., and Eyring, Henry, Mechanical Properties of Textiles, I, TEXTILE RESEARCH JOURNAL **15**, 295 (1945); Eyring, Henry, and Halsey, George, Mechanical Properties of Textiles, III, TEXTILE RESEARCH JOURNAL **16**, 13 (1946); *ibid.*, 284.

* Supplied through the courtesy of Messrs. Eavenson and Levering, Camden, New Jersey.

Mechanical Properties of Textiles, VIII

The Stress-Strain Relationship of a Plush Fabric

Henry Eyring* and George Halsey†

Contribution from The Textile Foundation and Frick Chemical Laboratory, Princeton University, Princeton, New Jersey

In this paper the spring-dashpot theory which has been applied in previous papers in this series to single fibers and to yarns is applied here to the experimental investigations of a plush fabric which have been published by Fox and Schwarz. This serves to outline the experimental methods which should be followed if the data are to have maximum theoretical significance.

THE previous papers of this series have been concerned chiefly with single fibers. A few results on yarns have been considered, but the behavior of a yarn is almost identical with that of its component fibers. However, when the yarn is made into a finished fabric, the mechanical properties are often altered fundamentally.

One would not expect a great change in the extensional properties of a material like canvas, but the compressional behavior of carpets seems difficult to estimate from the properties of the fibers themselves.

The general methods of the previous papers [2(*a*)] must be extended to such cases in order that the effects of component fiber material and of the structural nature of the textile can be separated.

Fox and Schwarz [1] have investigated the compressional stress-strain curves of some pile fabrics. Fortunately for the present papers, they published at least one repeated loading cycle curve (their Figure 4), the experiments having been performed at a constant rate of loading—that is, they were performed in such a manner that the results closely parallel those which would be obtained at a constant rate of loading in so far as the present authors can determine. Although the former authors point out the necessity of specifying the rates of experiment and modes of loading, they do not specify these rates in the preliminary studies they present. This complicates quantitative analysis of their data, but does not hamper the determination of the validity of several notions.

Examination of the Stress-Strain Curve

The essential requirement of the method outlined in the previous papers of this series can be expressed as follows: There must exist a "spring line" (a value of the force which is a single valued function of elongation alone) at which the instantaneous rate of viscous flow is zero.

In terms of repeated loading-cycle curves the existence of a reproducible "mechanically conditioned" curve after a number of cycles is symptomatic of a system of this type. That is, after a large number, n, of loading cycles, the stress-strain curve produced ceases to depend on n. The absence of secondary (irreversible) creep is a corollary of the existence of "mechanical conditioning." To be precise, one must be able to construct this curve—the spring line—in such a way that it makes a constant angle with the stress-strain curve wherever the two cross. This spring line is the line without arrows in Figure 1. It is parallel to the stress-strain curves whenever they may be construed as having yielded. Thus it parallels the loading curves at high load and the unloading curves at low load. Then, the difference between the spring curve and the stress-strain curve represents the force on the viscous part of the model. If this part is sensibly the same for every cycle, a so-called "working curve" exists [2(*b*)] and the treat-

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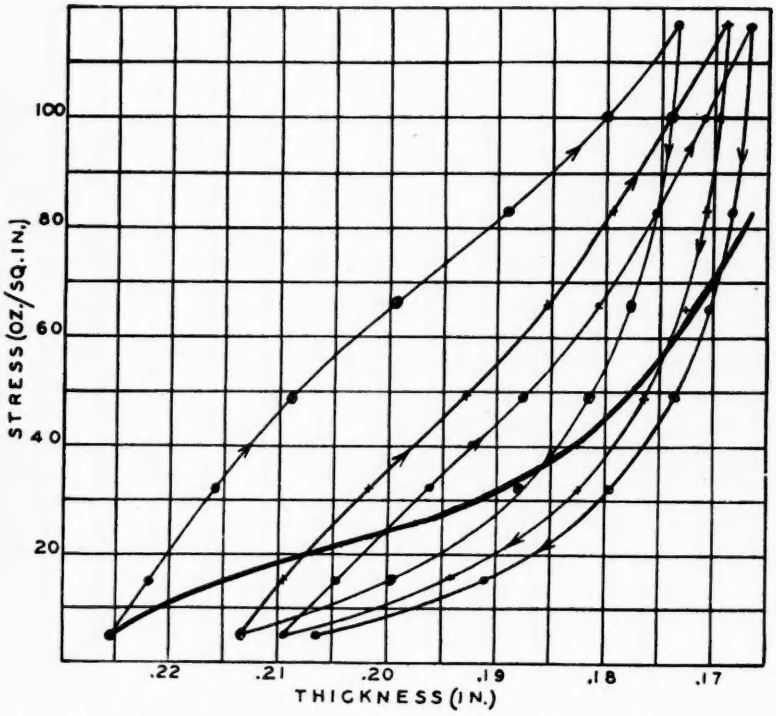


FIG. 1. *Fox and Schwarz' stress-strain curve for a plush fabric, with the authors' spring line added.*

ment is very simple—that of the three-element model with symmetrical potential barrier.

If two working curves are required—that is, one for elongation and the other for contraction (see the two full curves in Figure 2)—the situation is that of the three-element model with unsymmetrical barrier, as treated for the case of wool [2(*d*)]. If no single working curve applies but the yield stresses are all equal, all portions of the theory for a symmetrical potential barrier concerned with ultimate values hold. If the yield stresses are different with the direction (loading and unloading) but equal in one direction, the formal method of unsymmetrical barriers of Paper VII still applies, as it is concerned only with ultimate values. If the yield values fail to satisfy even this last criterion, and the spring curve exists, it is evidence of a changing mechanism in the viscous process.

Interpretation of the Stress-Strain Curves

It is pertinent to inquire just why stress-strain curves are of any use to the textile industry. Certainly, fiber stress-strain curves are remarkably useless, as such, since textiles are seldom if ever employed as simple fibers. If they are analyzed into parameters, it can be imagined that they may be more or less helpful to the fiber-maker or breeder as control experiments. But even to be useful here, some rough correlation must exist between these parameters and the behavior of the finished textile. Thus, no matter how precise the fiber theory is, its utility is limited by this correlation. On the other hand, any theory of the behavior of the finished textile in terms of some other body of facts is utilizable immediately, even if it is not clear what relation this theory has to the behavior of the component fibers. Despite this fact, the bulk of scientific work (including that of the authors) has concerned single fibers or, at most, yarns. There is a vague feeling that the simple case of a fiber is more "fundamental" and easier to treat. Actually, it appears that, because of the relatively low stresses, secondary (permanent) creep is almost absent in whole textile mechanics, whereas it is certainly a factor in certain fiber experiments [2(*c*)]. The meaning that can be attached to the various elements into which the stress-strain curves, such as those in Figure 1, are analyzed is evident.

The spring line reflects the structural nature of the textile. As its slope increases, more and more of the fibers are bearing load. In a completely tight weave it would be the same as the corresponding curve for the fiber. If the molecular yielding process

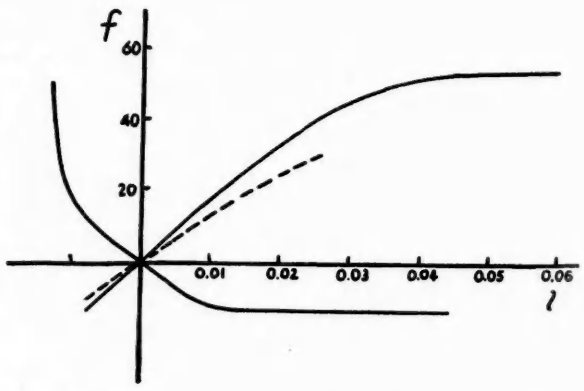


FIG. 2. *The working curves for Figure 1. The broken line represents the greatest deviation from the working curve. This deviation is typical of wool.*

in the textile can be identified with the yielding process in the single-fiber experiment, then several conclusions are available.

First, the symmetry of the potential barrier must be the same in both cases. This fact serves to test the hypothesis. The ratio of the flow volume represents the average concentration of stress. The change in K (reflected in the free energy of activation) represents the geometrical factor in the rate of flow—that is, when the over-all rate of elongation is ρ per second, then the actual rate, in all but single-fiber experiments, will be $G\rho$, where G is a purely geometrical factor.

To analyze the repeated loading-cycle curve of Fox and Schwarz, it is necessary, as has been shown, first, to synthesize the spring curve, using the top part of the loading curve and the bottom part of the unloading curves for slopes. A short extrapolation to zero also is necessitated. The whole process is illustrated in the arrowless curve of Figure 1. In this case it is apparent that an unsymmetrical barrier is required. The two working curves, the one for loading and the other for unloading in Figure 1, are presented in Figure 2. Because the experiment was conducted at only one rate, it is impossible to evaluate β. The data suffice to show that the symmetry coefficient of the potential barrier is equal to or less than 0.20.

With more complete experiments along the lines outlined in this paper, a complete study of the mechanics of this pile fabric could be made. To perform such experiments designed to be analyzed by these methods, it will be necessary to employ a machine that operates at a constant rate of loading or elongation. Stress-strain curves should be prepared at several widely differing rates, and should consist of a large number of repeated cycles. With these conditions, it should be possible to achieve a sound design theory for fabrics.

Literature Cited

1. Fox, K. R., and Schwarz, E. R., TEXTILE RESEARCH **11**, *227* (1941).
2. Mechanical Properties of Textiles:
   (*a*) I. Halsey, George, White, Howard J., Jr., and Eyring, Henry, TEXTILE RESEARCH JOURNAL **15**, 295 (1945).
   (*b*) III. Eyring, Henry, and Halsey, George, TEXTILE RESEARCH JOURNAL **16**, 13 (1946).
   (*c*) VI. Holland, H. D., Halsey, George, and Eyring, Henry, A Study of Creep of Fibers, TEXTILE RESEARCH JOURNAL **16**, 201 (1946).
   (*d*) VII. Halsey, George, and Eyring, Henry, The Visco-Elastic Properties of a Wool Fiber, TEXTILE RESEARCH JOURNAL **16**, 329 (1946).

Determining Fiber Fineness by Means of the Air Permeameter

George W. Pfeiffenberger

*A Contribution of The Research Division, Chicopee Manufacturing Corporation**

Summary

The need for a rapid and accurate method of determining cotton fiber fineness has led to experiments based on the resistance of various cotton samples to the passage of air. A fabric air permeameter has been redesigned to accommodate raw cotton. Experiments on a wide range of fiber fineness indicate a high correlation between air pressure readings and weight per inch.

The new method has several distinct advantages over the established method. The sampling is considerably better, since in present use the total sample employed is 7 grams, whereas in the generally accepted method the final data are based only on 1,000 to 1,400 fibers. A complete test can be made by the proposed procedure in about 4 minutes, whereas the established method requires approximately 3 hours. Other advantages are the elimination of expensive and delicate instruments, ease of training employees, and simplicity of operation.

Purpose of the Present Investigation

As a result of cotton fiber research conducted by a number of laboratories in recent years, considerable interest has been aroused regarding fiber fineness. Fineness can be defined as fiber diameter or fiber weight per unit length. Tests on the latter basis are much better known, and published data [1] on the subject are available. Extensive statistical analyses have shown that the property of fiber fineness is of importance with respect to yarn strength, and there is controversy over whether or not it also has an effect on neps and yarn appearance. Another importance of fineness is its use as one of the distinguishing attributes of a cotton variety. Although a given variety will vary in fiber fineness under differing growth conditions, a thoroughly bred cotton has a tendency towards a definite range of fineness. Fiber fineness, therefore, has possibilities as at least a partial means of variety identification.

Old Method

Probably the chief reason limiting more extensive study of cotton fiber fineness has been the slowness and tediousness of conducting the fineness test. The generally accepted method is to make a fiber array on a suitable device, such as the Suter-Webb sorter, and to extract with tweezers 100 individual fibers from each length group in the array. These fibers are weighed on delicate balances, and the weighted average fiber weight per inch is calculated. There is an improved variation of this method, in which the fibers are counted under the microscope instead of being extracted. In either method, however, considerable time is consumed, and a number of separate delicate operations, all susceptible to error, are

FIG. 1. *Photograph of the testing instrument, showing fluffy cotton samples.*

* This work was conducted at The Research Division Spinning Laboratory, in cooperation with the Texas Technological College, Lubbock, Texas.

necessary. It takes an average operator about 3 hours to make a complete test; and as the test is generally duplicated or triplicated for accuracy, the procedure is expensive and laborious. Furthermore, the original sample is composed of only 75 milligrams of cotton, and at completion of the test the actual weight-per-inch values are based on only 1,000 to 1,400 fibers. Even with the greatest care in sampling the original bale, the sample is minute and the method is open to criticism with respect to its representativeness.

Because of the proved importance of fiber fineness, it is imperative that a rapid and accurate method be developed if this knowledge is to be put into practical and commercial use. With this in mind experimenters turned their efforts to a method based on the principle of resistance to the passage of air through a weighed sample of cotton [2]. Preliminary experiments indicated a correlation between such air-resistance and fiber fineness, because the finer the cotton, the greater was the air-resistance offered by the sample. This resistance could be measured fairly easily by the use of water or oil manometers. In some of the early work, however, very small samples were used, which led to difficulties in positioning the sample in the holder and created considerable variation in the manometer readings for a single sample. Variations in atmospheric pressure may also have been responsible for some of the variations in results.

The instrument which forms the basis of the present work is a modified commercial device, originally designed for the testing of the air permeability of fabrics. The initial device was modified to the extent of removing the fabric sample-holder and mounting a newly designed chamber for raw cotton. The principle and the operation of the machine remain unchanged.

Proposed New Method

The Testing Instrument

Figure 1 is a general view showing the instrument and also the fluffy condition of the samples prior to testing. Figure 2 is a schematic diagram. As it now stands, the instrument [3] consists of a table to which are attached a rheostat, a suction-type fan, 2 air chambers, 2 manometers, and a sample-holder. An air orifice with a diameter of 2 millimeters is mounted between the air chambers. This orifice is constant, and its diameter is such that the widest range of cotton fineness can be measured with no calibration change in the instrument. The principle of the operation is as follows: Air is pumped out of chamber *B* and can be replaced only by air coming from chamber *A* through the orifice. The air entering chamber *A*, in turn, must come through the sample. If the cotton is fine-fibered it offers greater resistance to the flow of air and only a relatively small amount of air comes through the sample.

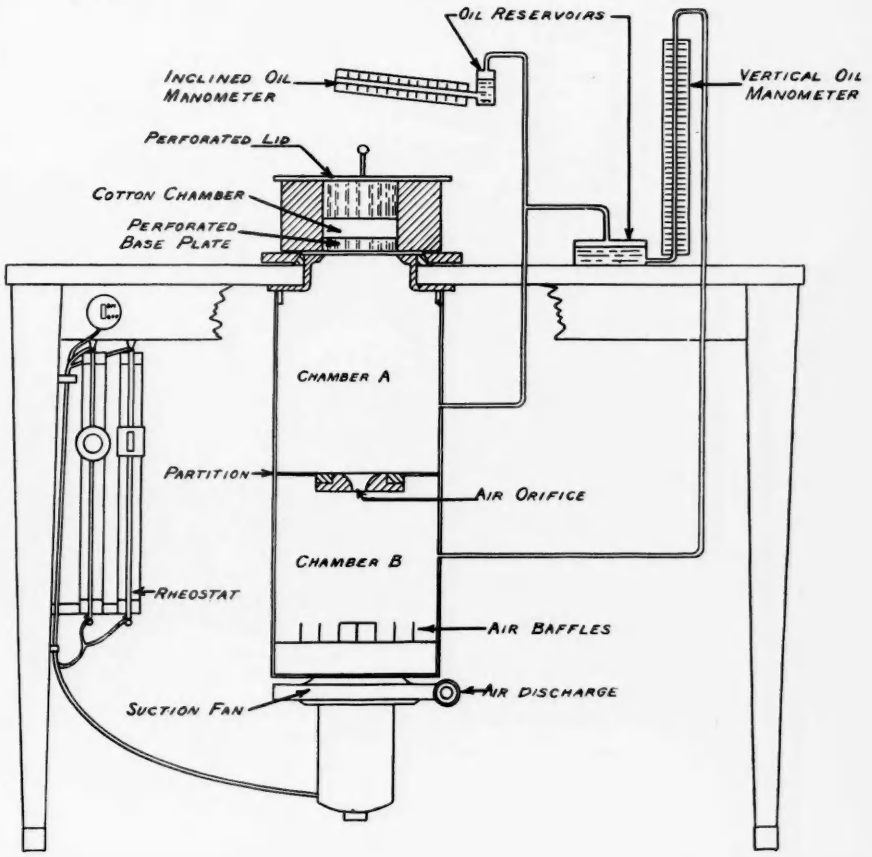


FIG. 2. *Schematic drawing of the air permeameter adapted for raw cotton.*

TABLE I. AIR PERMEAMETER READINGS, CHICOPEE CONVERTED WEIGHT PER INCH AND U.S.D.A. WEIGHT PER INCH OF 25 SAMPLES OF COTTON, CLEANED ON THE SHIRLEY ANALYZER (CROP OF 1942)

Fineness rank	Sample number	Pressure reading (cm.)	Converted * wt./in. (μg.)	U.S.D.A. wt./in. (μg.)
1	1929	8.6	3.2	3.2
2	1916	8.8	3.2	3.3
3	1966	10.5	3.5	3.6
4	1940	10.8	3.6	3.4
5	1934	12.0	3.8	3.8
6	1894	13.0	3.9	4.0
7	1912	13.1	3.9	3.4
8	1890	13.1	3.9	4.3
9	1918	13.3	4.0	3.8
10	1956	14.1	4.1	4.0
11	1893	14.4	4.2	4.4
12	1849	16.1	4.4	4.5
13	1946	16.7	4.5	4.3
14	1891	17.4	4.6	4.7
15	1863	19.0	4.8	4.9
16	1875	19.0	4.8	5.0
17	1872	19.7	4.9	5.2
18	1881	22.6	5.2	5.4
19	1862	24.6	5.4	5.5
20	1840	25.9	5.5	5.8
21	1864	26.4	5.5	5.7
22	1836	29.8	5.8	5.7
23	1975	29.8	5.8	5.8
24	1942	30.4	5.9	5.9
25	1842	30.4	5.9	6.3

* Converted by curve in Figure 3.

It is thus possible to maintain a constant pressure of 0.2 inch reading (on the inclined manometer) in the chamber *A* by operating the motor at slow speed. This slow speed, therefore, creates only a small air flow out of chamber *B* and there is only a slight rise in the oil in the vertical manometer. On the other hand, a coarse-fibered cotton which offers considerably less resistance permits air to flow more freely through the sample into chamber *A*. This makes it necessary to exhaust air more rapidly from *B*, in order to attain and maintain the constant pressure in chamber *A*. This increased air flow is indicated by a considerably higher rise in the oil in the vertical manometer. Varying degrees of fiber fineness, therefore, are indicated by the oil rise in the vertical manometer.

Development of the Testing Method

A large number of preliminary experiments were conducted in order to determine the optimum conditions for operation of the instrument. Various sizes of orifices, different pressure readings on the inclined manometer, various weights of samples, and various volumes and densities were tested. To simplify instrument calibration it was deemed advisable for the entire range of cotton fiber fineness to be measurable without the necessity of changing orifices and yet have the scale broad enough so that the instrument would be sensitive to small steps in fineness. To do this it was necessary to obtain a series of samples ranging from the finest to the coarsest cottons, and to adjust sample weights, densities, volumes, etc., so that readings for all the cottons would be within the limits of the scale, with the finest and coarsest reading close to the low and high ends of the scale, respectively. After many attempts the balance between capacity and sensitivity was attained, and at the present time it is possible to measure cottons ranging from the fine Sea Island and Egyptian varieties to the coarsest American Uplands on one scale without any recalibration of the instrument. This scale ranges from 0 to 40 centimeters.

One of the biggest problems in this work was to prepare the sample prior to testing. Samples of different waste contents offered some difficulty because of the varying amounts of leaf and trash which

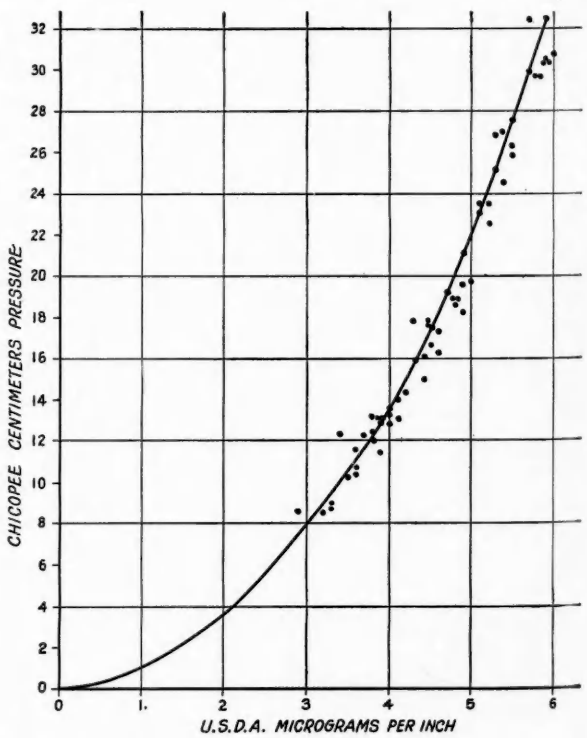


FIG. 3. *Old curve, showing relationship between Chicopee air permeameter readings and U.S.D.A. weights per inch.*

affected the results. Differences in readings were also obtained between hand- and machine-ginned samples, and between high- and low-density bales. It was found necessary, therefore, to partially clean and to "open" or fluff up all samples prior to testing. This was done at first by small hand combs, but there was a certain amount of operator variation, and readings were not always duplicated to a satisfactory degree. This problem of opening and cleaning was finally solved by the use of a small laboratory device [4] consisting of two wooden rolls covered with stripper wire. The teeth on the two rolls intermesh, and as the rolls are rotated the cotton passing between them is given a sort of combing action which fluffs up the lint and cleans it. This device puts all samples into approximately the same condition prior to testing, and greatly speeds up the preparation of the samples.

Description of Sample-Holder

The holder for the raw cotton sample is a simple device consisting only of a small chamber provided with a perforated floor and a perforated lid. The lid is turned down so that it fits snugly into the pipe, with its weight resting upon a flange or projection. By this means the weighed sample is always compressed to the same volume. In the early experiments a perforated disc was placed directly on top of the cotton in the sample-holder. This disc was closely fitted to the inside of the chamber and acted as a self-weighted piston. This was found to be unsatisfactory, as too much variability was obtained in the readings. The entire holder is mounted as shown in Figure 2, and is clamped down tightly to prevent air leakage.

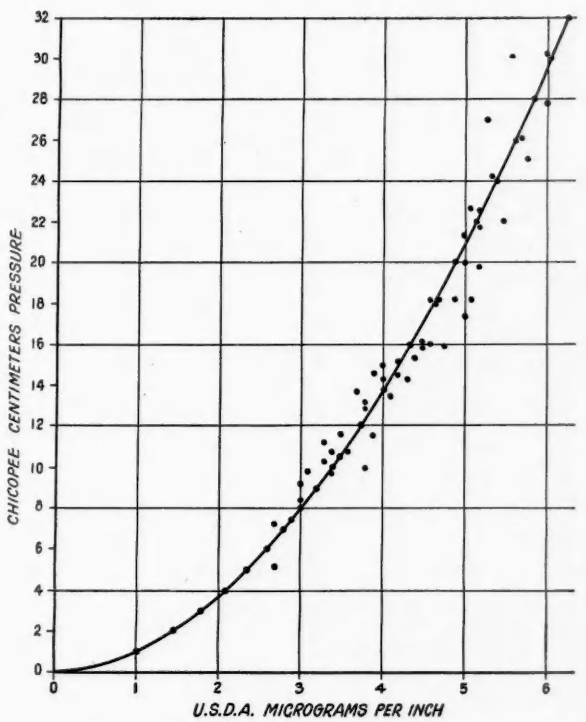


FIG. 4. *New curve, showing relationship between Chicopee air permeameter readings and U.S.D.A. weights per inch.*

TABLE II. AIR PERMEAMETER READINGS, CHICOPEE CONVERTED WEIGHT PER INCH AND U.S.D.A. WEIGHT PER INCH OF 25 RAW STOCK SAMPLES, HAND CLEANED (CROP OF 1943)

Fineness rank	Sample number	Pressure reading (cm.)	Converted * wt./in. (μg.)	U.S.D.A. wt./in. (μg.)
1	SxP	8.6	3.1	2.9
2	706	10.3	3.5	3.5
3	106	10.5	3.5	3.6
4	1702	11.5	3.7	3.9
5	1601	12.3	3.8	3.4
6	1705	12.3	3.8	3.7
7	107	12.9	3.9	4.0
8	502	13.1	4.0	4.1
9	511	13.2	4.0	3.8
10	1707	15.0	4.3	4.4
11	102	16.3	4.4	4.6
12	508	17.9	4.6	4.3
13	2005	17.9	4.6	4.5
14	302	18.3	4.7	4.9
15	1607	18.7	4.7	4.8
16	1904	19.8	4.8	5.0
17	1606	23.5	5.3	5.1
18	111	23.6	5.3	5.2
19	2230	26.9	5.6	5.3
20	2208	27.0	5.6	5.4
21	2206	30.2	5.9	5.9
22	1908	30.4	5.9	6.0
23	1909	32.4	6.0	5.7
24	1603	33.0	6.1	6.4
25	1604	33.4	6.1	5.8

* Converted by curve in Figure 3.

Fineness Testing Procedure

The performance of a test is simple. About 10 grams of cotton are opened and cleaned on the laboratory blender, which provides a fluffy mass of cotton for the test. From this prepared material two slugs of 3.5 grams each are carefully weighed, after being conditioned in a controlled atmosphere of 70°F and 65 percent R.H. The slug is placed in the sample chamber, the lid is put in place, and the motor is turned on. The rheostat is adjusted to control the speed of the motor until the inclined manometer is

stabilized at 0.2 inch pressure. When this point has been reached the reading of the vertical manometer is made. The motor is turned off and the lid is removed. The sample is turned over and the slug reinserted in the chamber without disturbing the shape. Another reading is made in the same manner. The second slug of cotton is handled in exactly the same way and the results are expressed as averages of the four readings. The difference in individual readings on the same slug is roughly indicative of the degree of experimental error in the method, whereas the difference between the average readings of the two slugs is an approximate measure of the variation in the cotton. Duplication of the four-reading average is possible within 2 or 3 centimeters, which is well within the limit of practical significance.

Interpretation of Results

Because of the extensive data already published on fiber fineness in terms of weight per inch, the pressure readings from this instrument have been converted into these terms. Fifty samples representing an extreme range in fiber fineness were tested by the established method at the College Station laboratory of the U. S. Department of Agriculture, Cotton and Fiber Branch, and the samples were furnished to this laboratory for permeameter testing. Twenty-five were cleaned on the Shirley Analyzer, and 25 by hand. The data from these tests are presented in Tables I and II, wherein it may be seen that little effect can be attributed to the method of cleaning. A sample-by-sample plotting was made of air pressure in centimeters against micrograms per inch. A clearly defined parabola was indicated from this plotting. The actual curve was calculated and the relationship between the pressure readings and the micrograms per inch is shown in Figure 3.

A second set of 50 case-historied cottons furnished by the U. S. Department of Agriculture was also tested. All these samples were opened and cleaned on the laboratory fiber blender previously described. The relationship between the permeameter readings and the weight per inch is shown in Table III and Figure 4.

To check the application of the conversion curves from one set of data to the other, the second set of 50 permeameter readings was converted to weight-per-inch values on the basis of both the curve shown in Figure 3 and that in Figure 4. The converted figures from the two curves are plotted against each other in Figure 5. The very close agreement indicates that either or both of the two parabolas could be used for converting pressure readings to weight per inch with little difference in the results. The

TABLE III. AIR PERMEAMETER READINGS, CHICOPEE CONVERTED WEIGHT PER INCH AND U.S.D.A. WEIGHT PER INCH OF 50 SAMPLES OF COTTON, TESTED BLIND

Fineness rank	Sample number	Pressure reading (cm.)	Converted * wt./in. New curve (μg.)	Converted * wt./in. Old curve (μg.)	U.S.D.A. wt./in. (μg.)
1	17	5.3	2.4	2.4	2.7
2	35	7.2	2.8	2.8	2.7
3	47	7.4	2.9	2.9	2.9
4	3	8.4	3.1	3.2	3.0
5	36	9.3	3.3	3.3	3.0
6	29	9.9	3.4	3.4	3.4
7	43	9.9	3.4	3.4	3.1
8	2	10.0	3.4	3.4	3.8
9	4	10.3	3.4	3.5	3.4
10	21	10.5	3.5	3.6	3.5
11	10	10.7	3.5	3.6	3.4
12	46	10.9	3.6	3.6	3.6
13	11	11.3	3.6	3.7	3.3
14	37	11.6	3.7	3.7	3.5
15	41	11.6	3.7	3.7	3.9
16	19	13.0	3.9	3.9	3.8
17	50	13.2	4.0	4.0	3.8
18	13	13.4	4.0	4.0	4.1
19	23	13.8	4.0	4.1	3.7
20	27	14.3	4.1	4.1	4.0
21	18	14.4	4.2	4.2	4.3
22	31	14.6	4.2	4.2	3.9
23	42	14.6	4.2	4.2	4.2
24	30	15.0	4.2	4.3	4.0
25	34	15.1	4.2	4.3	4.2
26	7	15.3	4.3	4.3	4.4
27	40	15.9	4.4	4.4	4.8
28	48	15.9	4.4	4.4	4.5
29	20	16.0	4.4	4.4	4.6
30	6	16.1	4.4	4.4	4.5
31	16	17.4	4.6	4.6	5.0
32	28	18.1	4.7	4.7	4.6
33	14	18.1	4.7	4.7	5.1
34	33	18.1	4.7	4.7	4.7
35	45	18.2	4.7	4.7	4.9
36	39	18.4	4.7	4.8	4.4
37	9	19.8	4.9	4.9	5.2
38	22	20.0	4.9	4.9	5.0
39	25	21.3	5.1	5.0	5.0
40	26	21.8	5.2	5.1	5.2
41	15	22.0	5.2	5.1	5.5
42	32	22.4	5.2	5.2	5.2
43	8	22.7	5.3	5.2	5.1
44	12	24.2	5.4	5.4	5.4
45	38	25.3	5.6	5.5	5.8
46	44	26.1	5.7	5.5	5.7
47	49	27.0	5.8	5.6	5.3
48	5	27.8	5.9	5.7	6.0
49	24	30.1	6.1	5.9	5.6
50	1	30.3	6.1	5.9	6.0

* Old curve is Figure 3; new curve is Figure 4; air pressure readings converted by these curves.

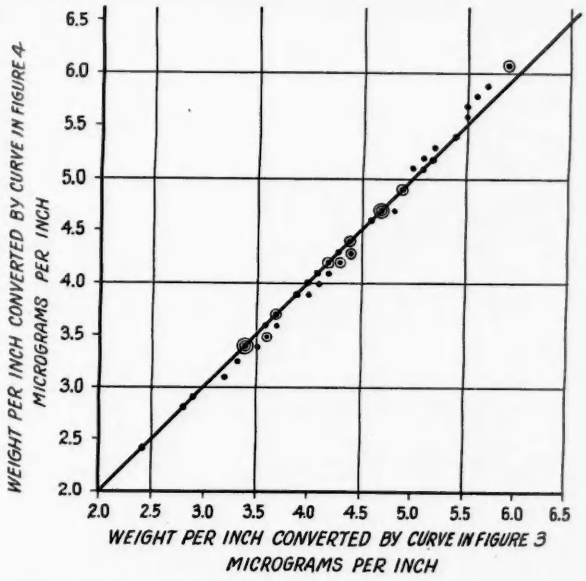


FIG. 5. *Graph showing relationship between weight-per-inch values converted from pressure readings by two different curves. Circles represent additional readings falling on same point.*

fact that the two parabolas were constructed from entirely different sets of readings proves that the relationship between the pressure readings and the weight per inch is consistent.

Acknowledgments

Credit and appreciation are due Dr. J. W. Wright of the U. S. Department of Agriculture, Cotton Branch, for furnishing the samples and the weight-per-inch data, without which this work would have been almost impossible. Acknowledgment is made of the assistance of Miss Ruby E. Stewart, Chicopee Laboratory, and Miss Lucille Finley, Texas Cotton Research Committee, for conducting the laboratory work and making valuable suggestions during development of the method.

This work was done in the cooperative fiber laboratory of Texas Technological College, Lubbock, Texas.

Literature Cited

1. (*a*) Results of Fiber and Spinning Tests for Some Varieties of Upland Cotton Grown in the United States (crop of 1944), United States Department of Agriculture, April, 1945. Results of Fiber and Spinning Tests for Some Varieties of Upland Cotton Grown in the United States (crop of 1945), United States Department of Agriculture, March, 1946.
   (*b*) Webb, R. W., and Richardson, H. B., Relationships Between Properties of Cotton Fibers and Strength of Carded Yarns (March, 1945); Relationships of Cotton Fiber Properties to Strength and Elongation of Tire Cord (June, 1945); Relationships Between Properties of Cotton Fibers and Appearance of Carded Yarns (March, 1946). U. S. Department of Agriculture, Cotton Branch.
2. Based on experiments conducted by Dr. K. L. Hertel, University of Tennessee, Mary Anna Grimes, Texas Agricultural Experiment Station, and George W. Pfeiffenberger, formerly of U. S. Department of Agriculture. Unpublished.
3. Schiefer, Herbert, and Boyland, Paul M., National Bureau of Standards, Research Paper RP 1471, May, 1942.
4. Stewart, Ruby E., A Fiber Blender, TEXTILE RESEARCH JOURNAL **15**, 468 (Dec., 1945).

Book Reviews

Advances in Protein Chemistry, Vol. II. M. L. Anson and John T. Edsall, editors. New York, Academic Press, 1945. 443 pages. Price, $6.50.

(Reviewed by Frederic R. Senti)

Volume II in this series, like the preceding volume, is a collection of very loosely related review articles, with major emphasis, perhaps, on protein analysis. The list of topics given below reveals the wide range covered.

Analytical Chemistry of the Proteins, by A. J. P. Martin and R. L. M. Synge; The Microbiological Assay of Amino Acids, by E. E. Snell; The Amino Acid Composition of Food Proteins, by R. J. Block; The Relationship of Protein Metabolism to Antibody Production and Resistance to Infection, by P. R. Cannon; Terminal Amino Acids in Peptides and Proteins, by S. W. Fox; The Copper Proteins, by C. R. Dawson and M. F. Mallette; Mucoids and Glycoproteins, by K. Meyer; The Reactions of Formaldehyde with Amino Acids and Proteins, by D. French and J. T. Edsall; Wheat Gluten, by M. J. Blish; Protein Denaturation and the Properties of Protein Groups, by M. L. Anson; X-Ray Diffraction and Protein Structure, by I. Fankuchen.

More space is given to the discussion of copper proteins than to any other subject in the collection. While the article is a very good one, it is felt that the editors might well have devoted some of this space to other topics.

Most of the articles are extensive, authoritative, and judicious. The review of the analytical chemistry of proteins, for example, covers the field of general methods of amino-acid analysis very thoroughly in 83 pages. Specific amino acids are not dealt with in detail, but an extraordinarily extensive bibliography of nearly 800 papers is included. The authors allot more space to adsorption methods and less to the isotope-dilution technique than their relative future importance would appear to justify.

The article on microbiological assay of amino acids is one of the most satisfactory in the book. It is clear, critical, objective, and very well organized. The author gives an excellent summary of the criteria of reliability.

There are a number of chapters of interest and potential value to the protein-fiber chemist. The chapters on amino-acid analysis, for example, are important in the light of the profound influence of amino-acid makeup on protein-fiber properties. Thus the most fundamental cause of the great difference in behavior between silk and wool is undoubtedly amino-acid composition. The interesting chapter on terminal amino acids offers a possible mode of attack for a problem of great significance for protein-fiber technology—namely, whether the protein molecule consists of one or several polypeptide chains. It is evident from the author's discussion, however, that the development of truly reliable and convenient methods still lies in the future.

Another problem encountered in the production of artificial protein fibers is that of rendering the fibers water-resistant. Treatment with formaldehyde has been commonly used for this purpose. The well-written chapter on reactions of formaldehyde with amino acids and proteins is, therefore, of considerable interest to those engaged in protein-fiber work.

In the brief but well-written chapter on x-ray diffraction, the structural aspects of protein fibers, viruses, and crystals are discussed. The discussion of fibrous proteins is devoted mainly to the recent work on the long-range periodicity occurring in the naturally fibrous proteins, keratin and collagen. Unit-cell dimensions and x-ray molecular weights of all proteins examined as single crystals are tabulated and are compared with molecular weights obtained by other methods. The difficulty of unique structure determinations in substances as complex as proteins is emphasized.

Spectrophotometric and Colorimetric Determination of the Colors of the TCCA Standard Color Cards. Genevieve Reimann, Deane B. Judd, and Harry J. Keegan. *J. Opt. Soc. Am.* **36**, 128–59 (Mar. 1946); *J. Research Natl. Bur. Standards* **36**, 209–47 (Mar. 1946), RP 1700.

(Reviewed by Dorothy Nickerson)

This report is a milestone in practical colorimetry. In sponsoring this work at the National Bureau of

Standards, the Textile Color Card Association of the United States has done a service both to the textile industry and to all color technology.

Table V gives adopted color specifications for the 216 samples (matte side) of the TCCA Standard Color Card of America, ninth edition, and for the 22 samples (grosgrain portion) of the U. S. Army Color Card. They are given in the three different ways recommended by ASA American War Standard Z44-1942, and may therefore be conveniently related to existing color specifications so that extension of the present use of TCCA standards may be facilitated. Specifications are given in terms of (1) I.C.I. Y and x, y, (2) Munsell notation (both renotation and book notation), and (3) ISCC-NBS color designation.

The importance of the work does not lie so much in the specifications alone as it does in the thorough study and report of the detailed cross-checks and the comprehensive closing check under conditions of use. The TCCA standards comprise the first extensive series of material color standards to receive this kind of study.

Familiarity with this report will afford the textile man an opportunity to adopt the method of colorimetry that may best suit him—whether it be the very direct and simple method of visual comparison to Munsell standards, or the most careful of spectrophotometric work—yet enable him to understand the many conditions that must be taken into consideration if in everyday work he is to rely upon results so obtained. To mention only a few of the conditions that are discussed in the paper, the following must be understood: (1) illuminating and viewing, both as regards quality and geometry to provide conditions similar to those in use; (2) fluorescence of samples; (3) luster of surfaces, both as it results in reflection of polarized light because of weave regularity, and the dependence of the color on the direction according to which it is illuminated and viewed; and (4) metamerism (pairs of samples visually identical but spectrally quite different).

Much of the detailed check work was done after it was found that there was a discrepancy for many samples when visual and instrumental results were compared. Over half of the samples were found to be noticeably fluorescent. The report shows that "although the spectrophotometric technique recommended by Z44-1942 is often inapplicable to fluorescent samples themselves, colorimetric comparison with non-fluorescent standards previously calibrated by that technique is a practical way of following the provision in Z44-1942 . . ." as regards basic specification.

The colorimetric data, given in accord with ASA war standard Z44, make the TCCA standards more useful not only to the textile man but to all colorimetrists. Among other things the data indicate that they cover important color ranges not covered by any other set of material standards calibrated for average daylight.

Color Measurement and Its Application to the Grading of Agricultural Products. A Handbook on the Method of Disc Colorimetry. Dorothy Nickerson. Washington, U. S. Department of Agriculture, March, 1946. Misc. Pub. 580, 62 pp., illus. Price, 25¢.

This publication contains a general introduction to color measurement for those interested in the subject as it relates to grading work; it also serves as a handbook on the method of disc colorimetry. While examples are taken chiefly from agriculture, enough material of a general colorimetric nature is included to supply the student with a background of authoritative information on any other type of problem involving color measurement and specification, textiles included. Grading problems, color charts, standards for transparency, physical and psychological methods of color measurement, and spectrophotometric and colorimetric methods of specification are all briefly discussed. Methods of color notation are described and related: (1) I.C.I. (Y, x, y)-notation, (2) dominant wave length—purity notation, (3) Munsell hue-value-chroma notation. About half of the report relates to disc colorimetry and its application to grading problems, starting with a very simple type of disc method through to the use of the disc colorimeter made by the Bausch and Lomb Optical Company. Several related subjects are discussed: the Kelly mask method for color matching, the ISCC-NBS standard names for color, the ASA standard (Z44-1942), color tolerance specifications, artificial daylighting, and color-vision testing.

Rubber in Engineering. Prepared under the direction of the Controller of Chemical Research of the Ministry of Aircraft Production and the Admiralty on the Basis of Research carried out by the Imperial Chemical Industries, Ltd. Reprinted by photo-offset

with permission of the Controller of His Britannic Majesty's Stationery Office. 304 pages, illus. Brooklyn, N. Y., Chemical Publishing Company, 1946. Price, $5.50.

(Reviewed by George Halsey)

This remarkable book is divided into several sections, which are as follows: Part I—(15 pp.) The Rubber-Like State; Part II—(120 pp.) The General Properties of Rubber; Part III—(15 pp.) Rubber Technology; Part IV—(70 pp.) Principles of the Design of Rubber Engineering Components. Various appendices make up the balance.

Although its small size has made the inclusion of theoretical derivations impossible, the authors have intelligently and briefly described the bases and results of these investigations, with good references to the literature. There is no wordy watering down of difficult discussions which is so typical of a certain level of engineering literature.

Abounding with good tables and curves, Part II would seem to be extremely useful to the engineer in search of numerical data, or even to the theoretical worker seeking raw material. If such a compendium of data concerning the mechanical properties of textiles had existed, some of the present writer's tasks would have been simplified.

Part IV contains, wherever possible, quantitative engineering design calculations in outline form, along with important observations on the validity of the tests upon which these calculations must be made.

In short, this book is a very concise compendium of facts about rubber, complete with literature citation.

ABSTRACTS

SERVICES AVAILABLE

Reprints of the original articles abstracted in TEXTILE RESEARCH JOURNAL *are often available from the publishers. Otherwise, it may be possible to secure copies of the periodicals. Orders should be sent direct to the publishers.*

Photostat negatives of articles abstracted will be furnished to members of the Institute at a cost of 20 cents per page for pages not exceeding 7 inches in width and 30 cents per page for larger sizes up to 11½ x 14 inches. Photostats of patents are 30 cents a page. Postage will be added.

Microfilm copies and paper enlargements of microfilm may be obtained from: Microfilms Inc., 313 N. First St., Ann Arbor, Mich.; New York Public Library, New York, N. Y.; Yale University Library, New Haven, Conn.; Harvard University Library, Cambridge, Mass.; and Library of Congress, Washington, D. C. Translations may also be obtained from the above sources.

A list of periodicals, the abbreviations used in references to articles, and the addresses of publishers of English language publications is given on page 84 of the February, 1946, issue.

ANALYSIS: TESTING: LABORATORY METHODS

★

Detection of Amylose

Estimation of iodine color of starches and starch fractions. Stanley A. Watson and Roy L. Whistler. *Ind. Eng. Chem., Anal. Ed.* **18**, 75–6 (Jan. 1946).

The colors of various starches and starch fractions in aqueous suspensions containing 0.03% starch (pH 4 to 6) with 0.01*N* iodine in aqueous potassium iodide (0.014*N*) are classified in accordance with the Munsell and Ridgeway color charts. The method is especially useful in determining the purity of amylopectin fractions and detecting the presence of small amounts of amylose. A. R. Macormac

Text. Research J. July 1946

Analysis of Detergents

Direct volumetric determination of the organic sulfonate content of synthetic detergents. T. U. Marron and Joseph Schifferli. *Ind. Eng. Chem., Anal. Ed.* **18**, 49–50 (Jan. 1946).

A method has been developed for the quantitative determination of sodium alkylbenzene sulfonates which is applicable to commercial detergents containing alkyl or alkylaryl sulfonates. Under standardized conditions *p*-toluidine hydrochloride reacts with these organic sulfonates to give aminosulfonate salts which can be subjected to rapid and relatively precise quantitative analytical determination suited to the requirements of industrial laboratories. Authors

Text. Research J. July 1946

Analysis of Fungicides

Quantitative determination of phenolic fungicides. Sidney Gottlieb and Paul B. Marsh. *Ind. Eng. Chem., Anal. Ed.* **18**, 16–19 (Jan. 1946).

The color reaction of 4-aminoantipyrine with the textile mildew-preventative 2,2′-methylene bis(4-chlorophenol) in the presence of potassium ferricyanide and dilute sodium carbonate has been found adaptable to quantitative analysis for this phenolic material and has been used for its determination in fabrics. Absorption curves and standard calibration curves are given for several other commercially important phenols, with the suggestion that this color reaction may find application in the quantitative determination of many phenolic fungicides, germicides, and other material. Authors

Text. Research J. July 1946

Analysis of Oils

Microdetermination of the saponification number of fats and oils. Kalman Marcali and William Rieman, III. *Ind. Eng. Chem., Anal. Ed.* **18**, 144–6 (Feb. 1946).

Methods are described for determination of the saponification number of fats and oils with samples of approximately 500, 50, and 5 mg. Authors

Text. Research J. July 1946

Analysis of Moth-Damaged Wool

Uric acid determinations on moth-damaged wool. A. Bolliger. *Australian J. Sci.* **8**, 22 (1945) (through *Chem. Abstr.* **40**, 2989[1] (May 20, 1946)).

High uric acid contents (0.1–0.5%) were found in moth-damaged wool samples, owing to the presence of moth excrement. Determination of the uric acid content of wool dust is suggested for qualitative diagnosis of insect damage and for quantitative estimation of the extent of damage.

Text. Research J. July 1946

Electron Microscope Attachment

A diffraction specimen holder for electron microscopes. G. L. Simard and C. R. Stryker. *Rev. Scientific Instruments* **16**, 146–8 (June 1945).

A specimen holder which permits the electron microscope (RCA model B) to be used for electron-diffraction studies is described. T. J. Dietz

Text. Research J. July 1946

Electron Microscope Sample Mounting

Filmless sample mounting for the electron microscope. John H. L. Watson. *J. Applied Phys.* **17**, 121–7 (Feb. 1946).

A procedure is described for preparing specimens of airborne particles for electron microscopic examination by trapping the particles on a matrix of thin glass fibers. An improvement in contrast and resolution is claimed. The method is considered to be particularly useful in the study of carbon blacks.
Text. Research J. July 1946

Fatigue Tester

Standard fatigue tester for use by the rayon manufacturers. Report to Committee D-13. W. H. Bradshaw. *A. S. T. M. Bull.* No. **136**, 13–17 (Oct. 1945).

Various instruments and the test procedures are described. It is urged that none of the present instruments be adopted as a standard. A. R. Martin
Text. Research J. July 1946

High-Speed Microtome

A high-speed microtome for the electron microscope. Ernest F. Fullam and Albert E. Gessler. *Rev. Scientific Instruments* **17**, 23–35 (Jan. 1946).

A high-speed, electrically driven microtome for use in preparing thin sections for electron micrography is described. Techniques and embedding materials are discussed, and electron micrographs of several substances are shown to demonstrate the applicability of the tool.
Text. Research J. July 1946 T. J. Dietz

High-Speed Photography

High-speed photography of the cathode-ray tube. H. Goldstein and Paul D. Bales. *Rev. Scientific Instruments* **17**, 89–96 (Mar. 1946).

Some of the techniques which are being used in the high-speed photography of single traces on the cathode-ray oscilloscope are discussed. The adaptation of 16-mm. cameras to permit photographing at speeds up to 4,000 traces per sec. is described. T. J. Dietz
Text. Research J. July 1946

New Device for Spectrophotometry

Device to facilitate the reading of spectrophotometric curves. Genevieve Reimann and Earl J. Carmine. *J. Opt. Soc. Am.* **36**, 235–6 (Apr. 1946).

This portable instrument is designed to eliminate or reduce many of the eye movements ordinarily necessary in reading spectrophotometric curves. This is done by bringing into easily controlled juxtaposition the curve, the wave-length scale, and the reflectance scale. The device is applicable both to the selected and weighted ordinate methods of calculation, may be used with or without wave-length correction, and is particularly useful when there are several curves to a sheet. The abstractor has used the instrument and finds it simple and practical to operate, with a considerable saving of eyestrain and time. D. Nickerson
Text. Research J. July 1946

CHEMICAL AND PHYSICAL RESEARCH

★

Abrasion-Resistance

Comparison of abrasion-resistance with other physical properties. F. N. Upham. *Rubber Chem. Tech.* **18**, 405–6 (Apr. 1945).

Data are presented to show that abrasion-resistance is more sensitive to variations in time of cure than are other physical properties.
Text. Research J. July 1946 W. E. Davis

Acetone Derivative of Carbohydrates

The acetone derivatives of hexahydric alcohols. Part I. Triacetone mannitol and its conversion into *D*-arabinose. L. F. Wiggins. *J. Chem. Soc.* 1946, 13–14 (Jan. 1946).

Evidence is presented for the structure of fully acetonized mannitol as 1:2-3:4-5:6-triacetone mannitol. Its graded hydrolysis yields 3:4-monoacetone mannitol and also 1:2-3:4-diacetone mannitol which is converted through oxidation with lead tetra-acetate into diacetone *aldehydo-D*-arabinose and thence into *D*-arabinose. Author
Text. Research J. July 1946

Preferential Adsorption of Rubber by Carbon Black

The mechanism of reinforcement. II. George Goldfinger. *J. Polymer Research* **1**, 58–62 (Jan. 1946).

Further experimental evidence is given which indicates that when a dilute solution of GR-S is mixed with carbon black certain fractions of the rubber are preferentially adsorbed by the black. After removal of the carbon black and adsorbed fraction by centrifuging, the treated GR-S is obtained by precipitation from the solution. Samples compounded as GR-S gum stock showed increasing modulus with increasing amounts of carbon black used for adsorption treatment. However, when the GR-S thus treated is compounded with carbon black, then the effect is reversed. The more black used in the treatment and the higher the modulus of the gum stock, the lower the modulus of the loaded stock.
Text. Research J. July 1946 Author

Effect of Carbon Black in Rubber

The mechanism of reinforcement. G. Goldfinger. *Rubber Chem. Tech.* **18**, 286–91 (Apr. 1945).

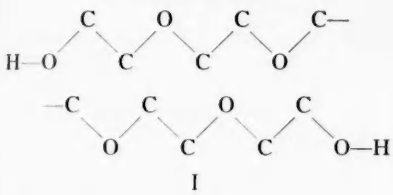
In evaluating the influence of reinforcing pigments, such as carbon black, on rubber, it has usually been assumed that the properties of the material between the filler particles are those of the original gum stock without pigment. This paper presents data which show that this is not true for carbon black; the carbon particles adsorb a fraction of the rubber, and the material which is left has a higher tensile strength

and shows a more rapid increase of viscosity with concentration than the adsorbed fraction. W. E. Davis
Text. Research J. July 1946

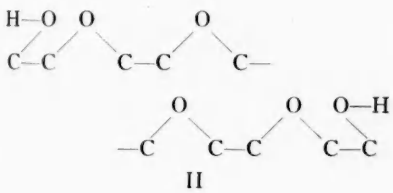
Carbowax

The dipole moment of Carbowax 4000. W. J. Svirbely and John J. Lander. *J. Am. Chem. Soc.* **67**, 2189–90 (Dec. 1945).

Carbowax 4000 is a polyethylene glycol, 90% of which consists of polymers with molecular weights between 3098 and 4418. 2 of the simplest structures are *I* and *II*. *I* would have a dipole moment of 2.24D and *II* of 150D. The dipole moment of Carbowax has been found to be 9.91D. Neither structure *I* nor structure *II* can be correct for Carbowax 4000.



I



II

A. R. Macormac
Text. Research J. July 1946

Concentrating Colloidal Dispersions

The method of purifying and concentrating colloidal dispersions by electrodecantation. Paul Stamburger. *J. Colloid Sci.* **1**, 93–103 (1946).

Electrodecantation is a process for concentrating a colloidal dispersion by electrodialysis and separating the concentrate by automatic decantation. A brief historical survey and a description of the recent improvements in technique both on the laboratory and the commercial scale are given. The method has been used to concentrate rubber latex. The method compares favorably with evaporation and no trouble is encountered with foaming. E. D. Klug
Text. Research J. July 1946

Color Sensation Curves

On the basic sensation curves of the three-color theory. H. de Vries. *J. Opt. Soc. Am.* **36**, 121–7 (Mar. 1946).

Measurements of the basic sensation curves of the Young-Helmholtz 3-color theory are described according to a new method. The authors find that the I.C.I. blue sensitivity curve represents the absorption curve of the blue receptors, but that the I.C.I. red and green curves must be transformed. Tentative formulas for such a transformation are given. These results are in complete variance with the 4-color theory that supposes the eye to contain a substance showing opposite reactions to blue and yellow light. The authors believe that the curves suggested by Hecht cannot be reconciled with their position that differences smaller than 1% are unobservable. Further work will be done regarding transformed curves for the I.C.I. red and green sensation curves.
Text. Research J. July 1946 D. Nickerson

Structure of Soap Micelles

Structure of soap micelles indicated by x-rays and the theory of molecular orientation. I. Aqueous solutions. William D. Harkins, Richard W. Mattoon, and Myron L. Corrin. *J. Am. Chem. Soc.* **68**, 220–8 (Feb. 1946).

X-ray diffraction photographs indicate that if the soap solution is not too dilute (approximately 9% to 35%) the soap exists as plate-like micelles with the $—COO^-A^+$ groups in the water and the ends of the hydrocarbon chains adjacent. The micelles are 4 or more chains thick. The long or layer spacing (d) of soap micelles has been found to be expressed by the logarithmic relation $d = 2l + k \log(1/c)$, where l is the length of the molecule, k is a constant, and c is the weight of soap per g. of solution. Micelle layer spacings vary from 30 to 100 Å. In the plane of the layers of the soap, the Bragg short spacings are very nearly constant at 4.5 Å. There is a chain-to-chain distance of 5.4 Å. and an area per mol. of 26.4 sq. Å. Mixtures of potassium laurate and potassium myristate give values for layer spacings intermediate between the pure soaps. The addition of either NaCl or KCl increases the layer spacing but does not affect the short spacing. It is probable that KCl makes the micelles smaller while NaCl makes them larger.
A. R. Macormac
Text. Research J. July 1946

Structure of soap micelles as indicated by x-rays and interpreted by the theory of molecular orientation. II. The solubilization of hydrocarbons and other oils in aqueous soap solutions. William D. Harkins, Richard W. Mattoon, and Myron L. Corrin. *J. Colloid Sci.* **1**, 105–26 (Jan. 1946).

In aqueous solutions of potassium oleate of 15 to 25% concentration, the increase in the thickness of the oriented double layer of soap film plus single water layer by saturating with *n*-dodecane, *n*-heptane, triptane, *n*-hexane and *n*-pentane was found to increase rapidly with decrease in the length of the molecule of solubilized oil. The area per soap molecule in the layer of soap was not changed by the presence of a solubilized hydrocarbon layer. The thickness of the oil layers was found to be only about 40% of the increase in thickness of the double layer plus water, caused by the addition of the oil (for heptane, triptane, and ethyl benzene). No explanation of this is offered at present. Monomer layers (75% isoprene and 25% styrene) were found to decrease from as high as 16 Å. to zero when polymerized by the action of a catalyst. This shows that the polymer molecules cannot be held by the soap micelles.
Text. Research J. July 1946 E. D. Klug

Autoxidation of Polyisoprenes

The course of autoxidation reactions in polyisoprenes and allied compounds. Part XI. Double

bond movement during the autoxidation of a mono-olefin. E. Harold Farmer and D. A. Sutton. *J. Chem. Soc.* **1946**, 10–12 (Jan. 1946).

The peroxidation product obtained by photo-oxidation of 1,2-dimethylcyclohex-1-ene appears to contain both 1,2-dimethyl-cyclohex-1-ene-3-hydroperoxide and 1,2-dimethylcyclohex-2-ene-1-hydroperoxide in accordance with the radical hydroperoxidation hypothesis previously advanced, since its hydrogenation product contains about equal amounts of the corresponding saturated secondary and tertiary alcohols. The crystalline acidic byproduct obtained by the action of alkali on the hydroperoxidation product of either 1-methyl-cyclohex-1-ene or 1,2-dimethyl-cyclohex-1-ene is the dihydroresorcinol, 2-methylcyclohexan-1,3-dione. Author
Text. Research J. July 1946

Tackiness of Elastomers

Tackiness of GR-S and other elastomers. W. F. Busse, J. M. Lambert, and R. B. Verdery. *J. Applied Phys.* **17**, 376–85 (May 1946).

The complex physical property of materials called "tackiness" is analyzed, and the various factors involved in the so-called hand tests are discussed. Different factors may be critical with respect to tackiness of materials of diverse properties, such as rubber, printing inks, and adhesive tapes, for example. Two quantitative tests for evaluating these various factors are described. One of these tests is designed for evaluating pressure-sensitive adhesive tapes and involves the measurement of the force required to strip the tape from a glass plate at various rates. The end-point is taken as the time in secs. to remove 1 cm. of tape. The second test is designed particularly for rubberlike materials and consists in pressing a sample of the test material which is wound around a cylindrical mandrel against a similar sample secured to a flat plate. A compressive force of 565 *g* is used. The maximum force required to separate the specimens is then determined. The German tackifier for synthetic rubber, "Koresin," is evaluated, together with other materials for improving the tack of GR-S. Koresin is reported to be the most effective tackifier found. T. J. Dietz
Text. Research J. July 1946

Water-Resistance of Proteins

Water-resistance of proteins. Harold S. Olcott and Heinz Fraenkel-Conrat. *Ind. Eng. Chem.* **38**, 104–6 (Jan. 1946).

Proteins were treated with a number of organic reagents and the products examined for water-resistance by measurement of the uptake of water by pressed discs. Aryl and long-chain alkyl isocyanates and also aromatic acid anhydrides and chlorides proved most effective. A number of proteins yielded phenyl isocyanate derivatives showing 24-hour water-absorption of 1 to 2%. Phthalic anhydride gave products of low water-absorption with egg white and cattle hoof. Protein derivatives of low water-absorption showed a tendency to plastic flow without the addition of water as plasticizer. Authors
Text. Research J. July 1946

BLEACHING: DYEING: FINISHING

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Redox Potential of Vat Dyes

Fading and tendering activity in vat dyes. A new method for its diagnosis. Y. M. Waly, J. M. Preston, F. Scholefield, and H. A. Turner. *J. Soc. Dyers and Colourists* **61**, 245–55 (Oct. 1945).

In an attempt to discover the significant properties upon which activity in vat dyes depends (with reference both to tendering of cellulose substrate and to abnormal fading of one component of a mixed vat-dyeing), some aspects of the electrochemistry of these dyes were studied. It was found possible to obtain a value for the redox potential characteristic of any given vat dye in the dyed condition. This was accomplished experimentally through the use of potential mediators which overcame the difficulty of insufficient free contact between the molecules of the dye system and the electrode. If the characteristic potential, E_c, is determined first in the dark and then with the system illuminated, no significant change is observed with inactive dyes; with active dyes illumination causes the potential to become distinctly more negative, this shift being greater the more active the dye. Dyes which do not cause tendering on simple exposure but produce extensive damage if light is introduced during the dyeing process may be detected by the fact that they do not show a potential shift at pH 7.16 but do so when the dyeing is carried out at pH 12.6. K. S. Campbell
Text. Research J. July 1946

Waterproofing

Textile waterproofing. Anon. *Text. Weekly* **37**, 736, 738 (Apr. 12, 1946).

Waterproofing of khaki greatcoat material by the use of alum salts aided by a fat or wax emulsion is described. The fat emulsion is prepared by dissolving 12 parts of an emulsifying wax in as little water as possible using heat, adding 24 parts of stearic acid, boiling and stirring to obtain a good emulsion, and, finally, adding 120 parts of water to make the stock emulsion. 9 lbs. of aluminum sulfate, 3 pts. of aluminum acetate, and 1 pt. of the stock emulsion are combined with the water in a normal type of washer to make the waterproofing liquor, and the cloth is processed for 20 to 30 min. using a cloth-to-liquor ratio of 1 to 2. A waterproofing test is described in which water is dropped on the material for 5 hrs. at the rate of 18 drops per min., the material being held in a frame tilted to a 45° angle. H. J. Burnham
Text. Research J. July 1946

FIBERS: YARNS: FABRICS: MECHANICAL PROCESSES

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Shrinkage of Wool-Rayon Fabrics

Changes in the dimension of union fabrics during finishing. C. P.

Atkinson and C. S. Whewell. *Text. Recorder* **63**, 45, 46, 52 (Feb. 1946).

In recent years there has been considerable interest in fabrics made from wool in admixture with synthetic fibers. These mixture cloths have been finished in the same manner as corresponding all-wool cloths. However, because of the influence of the synthetic fibers, the two types of fabric will probably differ slightly in behavior. To obtain information on the shrinkages of cloths containing wool mixed with Fibro or Rayolanda when subjected to normal wool-finishing operations, ten mixtures were made into two widely different types of cloth. Differences between reed width and grey width of the fabrics were noted and dimensional changes on crabbing, scouring, milling, dyeing, and blowing were examined. It is evident that the greatest difference between all-wool and union fabrics is shown in the milling process. The synthetic fibers caused a reduction in the shrinkage occurring during finishing; the greater the amount of milling in a particular routine, the greater is the difference between the union fabric and a corresponding all-wool cloth. Furthermore, cloths containing Rayolanda shrink more than corresponding cloths containing Fibro.

A. L. Merrifield

Text. Research J. July 1946

Wool and Protein Rayons

Wool and protein rayons. Anon. *Text. Mercury and Argus* **114**, 435, 437, 451 (Mar. 22, 1946).

A review of recent progress, touching briefly on the control of the felting power of wool to obtain the desired degree of density and softness by chemical and mechanical means, the modification of molecular structure by means of ethylene sulfide vapor said to assist level dyeing, and protein rayons such as lanital, aralac, soybean fiber, and ardil. 12 literature and 4 patent references. H. J. Burnham

Text. Research J. July 1946

Flax Hackling

Efficiency in flax hackling. Anon. *Text. Recorder* **63**, 42–3 (Jan. 1946).

The foundations of linen yarn quality and trouble-free spinning are laid in the hackling department; these include the correct determination of pin gradation, sheet settings, and machine speeds to suit the requirements of the material being handled. It is desirable to modify the gradation of pinning and number of tools on different machines to cover suitably all types of materials. On a machine on which the pinning is too coarse or the range of tools too small for the fiber, an increased sheet speed is not satisfactory; nor does a reduction in sheet speed compensate for overpinning. A table gives the range of pin gradations for different types of flax, and diagrams illustrate the mounting of tools on the hackle sheet. A. L. Merrifield

Text. Research J. July 1946

New Knitting Machine

New model double-cylinder knitting machine. Anon. *Text. Recorder* **63**, 38–40 (Feb. 1946).

This machine has been constructed as a basic model which can be fitted with numerous attachments for the production of a wide range of products. The machine has many refinements and special features, being designed to insure simplicity of operation and maintenance, durability, and high productive efficiency. The speed of the machine, according to the gage, is 160–190 r.p.m. A. L. Merrifield

Text. Research J. July 1946

The Chemistry of the Laundry Process

Colloidal factors in laundering. Robert A. Phair. *Colloid Chemistry* **6**, 620–8 (1946) (through *Chem. Abstr.* **40**, 2312[6] (Apr. 20, 1946)).

Topics are: destructive action of acids on cotton (mineral acid sour and circles of destruction); winter damages (from sulfur fumes); soaps —the washing process; soap specks; action of hypochlorites and of alkali on oxycellulose; effect of pH on the bleaching bath; action of bleach on resins; effect of metal catalysts and of silicates; oily stains, their effects and removal; collodial clay and solvent soaps; polyphosphates for sequestration of Ca and Mg.

Text. Research J. July 1946

WAR RESEARCH ON TEXTILES*

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U. S. Research

Field Jacket

Development of an intermediate-weight field jacket. Naval Clothing Depot, Brooklyn, N. Y. O.P.B. Report PB 9419, 1945; 12 pp.; microfilm, 50¢—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* **1**, 827 (Apr. 26, 1946)).

Previous to the initiation of this project, only heavy jackets such as the alpaca-pile-lined winter jacket were provided for the use of Navy personnel. This project was initiated to provide an intermediate-weight windbreaker or field-type jacket which could be added to the Navy's list of special clothing items. Tables and designs are included in the report, Bureau of Supplies and Accounts' specification.

Text. Research J. July 1946

Waterproof Seams

Development of waterproof seams for jackets, parka, and trousers, rain, N-2 (Research Project 4). Naval Clothing Depot, Brooklyn, N. Y. O.P.B. Report PB 9418, n.d.; 12 pp.; microfilm, 50¢—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* **1**, 827 (Apr. 26, 1946)).

This project was instituted to improve the waterproofing of the seams of N-2 rain parka jackets and trousers. The method of waterproofing double-needle seams with three coats of butadiene-acrylonitrile and vinyl-chloride mixture requires no unusual skill. It is rec-

* Copies of the original reports abstracted in this section may be obtained from the U. S. Department of Commerce, Office of the Publication Board, Washington 25, D. C.

ommended that specifications be modified to allow double-needle, coated seams until such time as vulcanized seams are available.
Text. Research J. July 1946

German Research

Asbestos Textiles

The asbestos textile industry. Robert E. Cryor. O.P.B. Report PB 3879, 1945; 34 pp.; microfilm, 50¢—photostat, $3.00 (through *Bib. Sci. and Ind. Reports* **1**, 643 (Apr. 5, 1946)).

The purpose of this investigation was to inquire into the wartime operation of asbestos textile plants in Germany, and to determine the state of technical knowledge prevailing in the industry during the war and up to the present time. Machine output in German asbestos plants is generally much lower than corresponding American machine output, and the production much coarser and very low in quality by comparison. Asbestos textile plants in Germany are poorly organized generally, with respect to plant layout and the orderly flow of material in process. A decided absence of technical work and experimental development was noted. No new methods, machines, or labor-saving devices were observed. Results of a survey of the nature of equipment and methods observed in all of the asbestos plants covered by this investigation are given in a composite picture. "Synthetic" asbestos reported in Germany is a form of fibrous glass that is produced by the Schüller process. The production of a fibrous glass material capable of being carded and spun into yarns and the development of efficient carding and spinning techniques for this fiber are the only technical achievements observed in the German industry that have not been duplicated in the United States. The opinion of all persons interviewed is that the Schüller glass fiber has been an effective substitute for asbestos, and without it the industry could not have operated, but all agreed that if asbestos fiber were available, it would be the preferred material. The asbestos industry was the sole outlet for this Schüller process glass fiber, which process is described. The methods of processing the glass fiber into yarn, as developed by Hardt-Pocorny, are also described. The appendix contains the names, addresses, and historical data of the plants visited. Photographs are included.
Text. Research J. July 1946

Automatic Stop-Motion

Automatic stop-motion for individual bobbins on yarn twisting frame, at Lehrspinnerei, Denkendorf. (FIAT Final Report 551.) Henry D. Grimes. O.P.B. Report PB 8267, 1945; 2 pp.; microfilm, 50¢—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* **1**, 962 (May 3, 1946)).

In addition to the customary device for stopping the flow of roving to the rollers, this mechanism has another device attached to the same levers for dropping the drive belt from the bottom of the spindle to an idler pulley. Thus the spindle itself stops, greatly reducing the danger of doublings from its free-flying broken end. Drawing included.
Text. Research J. July 1946

Raw Materials for Cellulose

Study of use of other materials than wood or cotton as sources of cellulose. (FIAT Final Report 490.) Kyle Ward, Jr. O.P.B. Report PB 7755, 1945; 22 pp.; microfilm, 50¢—photostat, $2.00 (through *Bib. Sci. and Ind. Reports* **1**, 723 (Apr. 12, 1946)).

Straw cellulose pulp was manufactured by the Phrix-Gesellschaft in their plant at Wittenberge. This was the only successful use of straw in this way. At Wittenberge there was a chain of three plants, a straw pulp plant, a staple fiber plant operating on the pulp, and a food yeast plant utilizing the liquors from the pulp plant. The pulping process itself was in two stages, an acid hydrolysis for the pentosans and a sulfite cook thereafter. Many companies experimented with *Arundo donax* as a source of cellulose, but the only plant that carried on production (until destroyed by bombing during the war) was that of Snia Viscosa. The pulp plant, Tor-Viscosa, was situated at Torresuino, Italy. The pulp was produced by a special bisulfite process and was used by the various plants of the Snia Viscosa chain. Processes of pulping are described and comments from other sources given. The following materials are discussed as sources for cellulose: *Phragmites communis*, rape straw, bast-fiber wastes, potato vines, and other materials. Miscellaneous information on companies visited includes data on the regenerated fiber industry, cellulose acetate firms, nitration plants, and hydrolysis of cellulose. Names and addresses of firms visited in Austria, Germany, and Italy are listed. Special attention is given to Alex. Wacker Gesellschaft für Elektrochemische Industrie and the Wacker cellulose acetate process. The I. G. Farben group controls 50% of this company. An extensive list of products manufactured at the Burghausen plant are presented. Visits to the I. G. Farbenindustrie Dormagen plant manufacturing cellulose acetate, and the research group at Weinheim (displaced from Ludwigshafen), and to the Lonza-Werke at Waldshut, and the Lonzona, A. G., at Säckingen, are described at length. A bibliography is included in this report.
Text. Research J. July 1946

Dyeing and Finishing Woolens

Dyeing and finishing of woolens and worsteds in Germany. (FIAT Final Report 643.) Henry D. Grimes. O.P.B. Report PB 16098, 1945; 13 pp.; microfilm, 50¢—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* **1**, 1045 (May 10, 1946)).

The purpose of the work covered by this report was to procure information concerning procedures used in the dyeing and finishing of woolens and worsteds in Germany. Raw stock and yarns are dyed in nonpressure types of circulating

equipment and in pressure types of circulating machines, using the same kinds of dyes and procedures used in America. Considerable stainless-steel equipment is used in the yarn-dyeing machines. Piece dyeing was carried on in the usual dye kettles, and the conventional dyeing procedures and dyes were used. Finishing equipment in all instances was rather old. All processes, except the drying of fabrics, were conducted on the batch basis. No evidence of attempts to finish or dye goods on a continuous basis was found. List of woolen and worsted plants investigated is included.
Text. Research J. July 1946

Fiber-Glass Weaving

Fiber-glass weaving by Rheydt Glas-Weaving Company, Walter Klevers, Rheydt near München-Gladbach. (FIAT Final Report 552.) Ernest C. Geier. O.P.B. Report PB 8274, 1945; 2 pp.; microfilm, 50¢—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* **1**, 961 (May 3, 1946)).

The object of the work covered by this report was a study of the German method of weaving of fiber-glass, i.e., continuous-filament glass threads defined in German as *Glasseide*. The fiber-glass fabrics produced were strictly a war essential. Previous to that the mill made high-class silk and rayon materials. Although the mill was small, it was considered an important factor in the field of continuous glass-yarn weaving. Manufacturing operations are described briefly.
Text. Research J. July 1946

Fiber Processing

Textile reconnaissance memorandum No. 20, Emmendingen, Germany, June 20, 1945. Joseph P. Meierhans and John F. Hagen. O.P.B. Report PB 15982, 1945; 7 pp.; microfilm, 50¢—photostat, $1.00 (through *Bib. Sci. and Ind. Reports* **1**, 964 (May 3, 1946)).

Investigations of the bleachery and spinning plant of Erste Deutsche Gesellschaft, Emmendingen, Germany, revealed that the plants had been making cottonized flax from unretted fiber by chemical treatment and selling it to spinners having cotton-system equipment. The plants were processing flax and ramie both chemically and mechanically using waste-type machinery combined with a spun-silk-spinning system for the long fibers, and woolen cards combined with worsted-type gilling processes for the shorter fibers. Both the plants are destroyed.
Text. Research J. July 1946

Rayon Weaving

Observations of the rayon weaving and throwing industry in Germany. E. C. Geier. O.P.B. Report PB 16392, 1946; 32 pp.; microfilm, 50¢—photostat, $3.00 (through *Bib. Sci. and Ind. Reports* **1**, 1045 (May 10, 1946)).

A paper given before the A.A.T.T. on the German rayon weaving and throwing industry, based on an investigative tour in the British zone. German rayon firms are, in general, highly integrated, making everything from yarn to finished product. Not more than 20 to 25% of the industry can be put in production again by the end of 1946, even assuming that materials and fuel will be available. Manufacturing methods are commented on. The Germans are far behind the United States in weaving and throwing, mechanically and organizationally. Interesting developments were made during the war in throwing, particularly with respect to the Barmag double-twist spindle, a crepe spindle for high twist. Heddles made out of plastics are also described.
Text. Research J. July 1946

MISCELLANEOUS

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Air Conditioning

Air conditioning and dust control. S. Holt. *Text. Weekly* **37**, 378, 380, 382, 434, 436, 438, 493, 494 (Feb. 22, Mar. 1, Mar. 8, 1946).

An address on the correlation of air conditioning with the control of lint and fly in the cotton industry in which particular attention is paid to the card room. It is said that proper air conditioning improves the general health of the operators and cuts down absenteeism. Applying a hood to each card with its own fan and dust separator and returning the air directly to the room is advocated. On roving, it is said to be uneconomical to attempt the removal of dust and lint from the room, the practical and economical way to get a better atmosphere being increased use of air conditioning. H. J. Burnham
Text. Research J. July 1946

Classification of Cation-Active Compounds

Use of cation-active compounds in the textile industry. J. P. Sisley. *Industries corps gras* **1**, 7–13 (1945) (through *Chem. Abstr.* **40**, 2312[4] (Apr. 20, 1946)).

A classification for the cation-active compounds used in the textile industries is proposed. The derivatives of fats are divided into amines, with a fat acid chain, homologs of aromatic amines containing a fat acid chain, fat amide derivatives of aliphatic diamines, fat amide derivatives of disubstituted diamines, salts and hydrates of quaternary ammonium, fat amide derivatives of amino alcohols and their quaternary derivatives, quaternary ammonium bases of fat amides of disubstituted diamines, quaternary ammonium bases of benzimidazolines, compounds of pyridine and derivatives, sulfonated, phosphated, and antimonated compounds, and ammonium quaternary betainic compounds. The nonfat derivatives were divided into derivatives of choline, dimethyl-phenylbenzyl-ammonium chloride, urethans or basic salts of ethylenediamine, polyethylenediamines and their quaternary ammonium derivatives, polypropanol polyethanol amines, and condensation products such as anhydroformo-*o*-toluidine, and compounds of basic N compounds with an aliphatic aldehyde and salts of an amine.
Text. Research J. July 1946

Cellulose for the Rayon Industry

Wood pulp and cellulose supplies for rayon. Anon. *Silk and Rayon* **20**, 33–4 (Jan. 1946).

The rayon industry depends very largely on the resources of the forests as a means for providing raw material for rayon manufacturing. An analysis of the current and prospective statistical position of wood pulp in relation to supplies is given. A table gives the exports of wood pulp from leading countries for the years 1913, 1938, and 1939, and also shows the proportions of chemical and mechanical pulp for the year 1939. A. L. Merrifield

Text. Research J. July 1946

Deterioration in Egyptian Cotton

Measures to check deterioration in Egyptian cotton varieties. Part I—The Giza seed maintenance system. H. A. Hancock. *J. Text. Inst.* **36**, T267–T277 (Nov. 1945).

The effort to control deterioration in Egyptian cotton has led to the present government-operated Giza seed maintenance system. Every propagation bulk is expanded from a single plant selected out of a selfed line. The progeny of this plant pass through a "purity chequer." Each chequer consists originally of 100 plants. The results for each surviving plant (usually about 90) are plotted in scatter diagrams called "target diagrams." Plotting halo length against ginning out-turn is most useful. The 50 plants nearest the bull's-eye constitute a "type-group." These plants are bulked and expanded into a renewal nucleus from which all the commercial crop of that variety ultimately will be derived. In propagation, the renewal nucleus is maintained at the center of surrounding expansion zones. Every 3 or 4 years a fresh renewal nucleus is expanded from another pedigreed plant, a number of progeny are tested for yield and spinning quality, but only one is selected. By this procedure gradual improvement in a variety can be achieved. Under the provision of the Seed Control Law, seed intended for sowing must be ginned under government supervision and seed samples must meet certain specifications. Formerly, refusal was based on the elimination of offtype seeds, but since 1942–43, for long staple cotton, refusal is based on spinning tests. A dated seed system is being considered. Norma L. Pearson

Text. Research J. July 1946

Measures to check deterioration in Egyptian cotton varieties. Part II—Development of new varieties. H. A. Hancock. *J. Text. Inst.* **36** T278–T292 (Nov. 1945).

Formerly new varieties of Egyptian cotton were developed from offtypes found in established varieties. Greater and faster progress in cotton breeding is being made, however, by the hybridization method, using selections from pedigreed lines as parents. Hybrid lines constantly produce new strains which exceed the parental limits; the yield of Egyptian varieties of 10 years ago is exceeded today by half a dozen new varieties and the former upper limits of yarn strength have been exceeded frequently. The increase in range is ascribed to the accumulation and recombination of plus and minus modifiers, along the lines suggested by "Student" and by K. Mather. The method of developing, introducing, and perpetuating a new variety is described. Each succeeding renewal nucleus is derived from a later generation and thus the variety becomes purer the longer it is under cultivation. Extensive spinning tests are conducted on the hybrid and pedigreed-line families. A brief discussion is given of the effect of cotton breeding research on agricultural economics. Norma L. Pearson

Text. Research J. July 1946

Measures to check deterioration in Egyptian cotton varieties. Part III—Extent, nature, and cause of deterioration. H. A. Hancock. *J. Text. Inst.* **36** T293–T310 (Nov. 1945).

Even with the Seed Control Law in operation, yarn strength for a given variety was lower when grown commercially than when grown experimentally by the Ministry of Agriculture. The explanation for the deterioration was shown to be in the failure of the Seed Control Law to operate effectively on commercial seed. The law does not eliminate the offtype plants or seeds which are chiefly responsible for deterioration since they are indistinguishable from normal plants and seeds. The author is of the opinion that the actual cause of deterioration is the accumulation and later the expansion of minus modifiers which can be regarded as "wild type" genes. The serious deterioration of certain varieties had led to the strengthening of the Giza technique. New varieties were ruled not to leave the hybrid lines before the F_9 generation. Seed maintenance within the renewal nucleus came into operation. The spinning test method for seed elimination was adapted for all long-staple varieties and a dated seed system that will apply to all varieties is projected.

Norma L. Pearson

Text. Research J. July 1946

Cotton Marketing

Will Clayton's cotton. Anonymous. *Fortune* **32**, 138–147, 231-238 (Nov. 1945), 159–163, 231–242 (Dec. 1945).

History and operations of Anderson-Clayton Company, largest cotton merchandising firm, are described in detail. R. B. Evans

Text. Research J. July 1946

Quality of Cotton Crop

Cotton quality statistics, United States, 1944–45. Cotton Branch, Production and Marketing Administration, U. S. Dept. of Agriculture. Washington, Dec., 1945. 62 pp.

This report presents final estimates of the grade and staple of cotton produced during the 1944–45 crop year, for the nation and by states and districts, based on a 10% sample, with comparisons with previous years. Similar data are given on the Aug. 1st carry-over and on the supply and disappearance of cotton. Only 35% of the upland

cotton ginned during 1944–45 was middling or higher white and extra white as compared with 47% during the previous year, but 24% of the crop was $1\frac{1}{16}$ in. in staple or longer as compared with 19% in 1943–44. *Text. Research J. July 1946* R. B. Evans

United States quality report for ginnings 1945 crop. Cotton Branch, Production and Marketing Administration, U. S. Dept. of Agriculture. Washington, Mar. 21, 1946. 9 pp.

Grade of the 1945 crop was the lowest on record, with only 372,000 bales of strict middling and higher white and extra white as compared with 497,000 in 1944 and 1,638,000 in 1943. The crop's average staple, 32.2 thirty-seconds in., was the longest on record, comparing with 31.9 in 1944 and an average of 30.7 during 1933–37. Statistical tables give the distribution of the crop by grade and staple for 1944 and 1945, grade and staple indices by states for several years, and grade and staple differences in price and loan value. R. B. Evans

Text. Research J. July 1946

Peruvian Cotton

Five-year breeding to improve Peruvian cotton. H. Martin Leake. *Fibres* **7**, 13–15 (Jan. 1946); *cf.* TEXTILE RESEARCH JOURNAL **16**, 44 (Jan. 1946).

Nine-tenths of Peru's exports of cotton derive from a wilt-resistant, early-maturing *barbadense* plant giving a lint of great whiteness and adequate length selected by Tanguis. To reverse a trend towards deterioration, Harland, of the Institute of Cotton Genetics at Lima, initiated a program of selection based on an interesting policy of breeding which appears thoroughly to have justified itself. Discarding any idea of seeking genetical purity for the lint-length character alone—and thereby sacrificing desirable characteristics associated with genes which would be eliminated—Harland made no attempt at line breeding but based a rapid selection system on the 6 desirable commercial characteristics, employing fully the new technique of statistical method in genetics. Readers wishing to study this work in greater detail will find it fully reported in "The Selection Experiment with Peruvian Tanguis Cotton" by S. C. Harland (*Bull. 1*, 1944, Institute of Cotton Genetics, Lima). Author

Text. Research J. July 1946

Ginning Costs

The economics of cotton gin operation. D. Gray Miley and Arthur L. Roberts. Bulletin 421, Mississippi State College Agricultural Experiment Station. State College, Miss., July, 1945. 33 pp.

Ninety-two gins in central and northern Mississippi had an average gin income of $3.46 per bale in 1944, as compared with an average cost of $3.10, leaving a profit of $0.36 per bale. The profit from handling seed and bagging and ties increased this profit to an average of $1.96 per bale, but modern gins in the group averaged $2.25, whereas substandard gins averaged only $1.46. An average of 2.9 hrs. of man-labor was required per bale but modern gins used only 2.6 hrs. and substandard gins used 3.3 hrs. Gasoline engines were a cheaper source of power than Diesel engines or electricity. Since gins operate only a short period each year, investment costs are relatively high and profits depend on how near to capacity they can be operated and on efficiency of labor. Drying equipment was found to be effective in reducing rough preparation of cotton having excessive moisture. R. B. Evans

Text. Research J. July 1946

Flax Quality

Judging the spinning quality of green flax. Linen Industry Research Association, Lambeg. *Fibres, Fabrics, and Cordage* **12**, 500–3 (Dec. 1945).

Spinning quality of flax fiber, as measured on fiber strands ready for spinning, depends on properties of strength, fineness, and length. By use of the "LINRA Flax Analyser," a sample of cleaned fiber can be produced in a few minutes from straw or scutched fiber, permitting an appraisal of the fineness factor and better judgment of fiber strength before the fiber is hackled. *Text. Research J. July 1946* R. B. Evans

Effect of Fungi on Hemp

Biochemical changes involved in the decomposition of hemp bark by pure cultures of fungi. W. H. Fuller and A. G. Norman. *J. Bact.* **50**, 667–71 (1945); cf. *C.A.* **40**, 740[8] (through *Chem. Abstr.* **40**, 2311[2] (Apr. 20, 1946)).

The rate of decomposition and the biochemical changes involved when green, unretted hemp bark was inoculated with pure cultures of *Alternaria*, *Hormodendrum*, *Fusarium*, *Phoma*, *Trichothecum roseum*, and *Cephalosporium* incubated for periods of 5, 10, and 20 days were investigated. During the first 10 days the various fungi brought about approximately equal losses in total weight, but thereafter, *Alternaria*, *Cephalosporium*, and *Fusarium* continued a more vigorous rate of decomposition than the remainder. The various fungi appeared rather similar in their ability to attack the constituents of hemp bark. During the first 5 days both polyuronide and pectin were substantially attacked but there was little removal of cellulose until later. There was no indication that *T. roseum* was more destructive to cellulose than any of the other fungi in pure culture. *Cephalosporium* seemed to attack cellulose to a slightly greater degree than the other cultures.

Text. Research J. July 1946

Retting of Hemp

The nature of the flora on field-retting hemp. W. H. Fuller and A. G. Norman. *Soil Sci. Soc. Am., Proc.* **9**, 101–5 (1944) (pub. 1945) (through *Chem. Abstr.* **40**, 740[8] (Feb. 10, 1946)).

The predominant fungi found growing on hemp were species belonging to the genera *Alternaria*, *Hormodendrum*, *Fusarium*, *Phoma*, and *Cephalosporium*. *Alternaria* species and *Hormodendrum* species were also found on field-retting hemp and appeared most abundant throughout the retting process. Species of *Phoma* and *Cephalosporium* occurred

most frequently during the late stage of retting. *Fusarium* species developed most luxuriantly on the bottom hemp and during the early stages of retting. *Trichothecium roseum* was most active during warm, humid periods and caused rapid over-retting and deterioration of the fibers. An abundant supply of moisture had little effect on the nature of the fungal flora except to favor the growth of species of *Fusarium*. Bacteria appeared on field-retting hemp in substantial numbers, particularly during the periods when the moisture supply was not abundant.

Text. Research J. July 1946

Advances in Metallurgy

Metallurgical progress and the plastics industry. L. Sanderson. *Brit. Plastics* **18**, 40–3 (Jan. 1946).

New developments in the past year are briefly summarized here so that the engineer and the plastics designer may be made aware of possibilities and trends in this section of the industry. Author

Text. Research J. July 1946

Insect Damage to Nylon

Insect damage to nylon. R. L. Patton. *J. Econ. Entomol.* **38**, 522–3 (1945) (through *Chem. Abstr.* **40**, 1271[8] (Mar. 10, 1946)).

Nylon, finished completely or finished by the scouring process, is highly susceptible to damage by larvae of several species of dermestid beetles, particularly *Anthrenus verbasci*. Cotton cloth similarly treated is likewise damaged. A scour containing a sulfonated oil and Na silicate imparted the greatest attractiveness to the fabric; a sulfated alcohol which was both a scour and a finishing agent gave the second degree of attractiveness; a sulfonated oil, different from the first, imparted least attractiveness. Nylon is not digested by the larvae but may have a slight nutritive value. The tactile sense is of great importance in food selection by the larvae. The finish of the fiber is probably the critical factor in the attack by these insects.

Text. Research J. July 1946

Recent British Patents

Progress in rayons and textile auxiliaries. Anon. *Silk and Rayon* **19**, 1093–5 (Oct. 1945).

A brief discussion is given of the following subjects: (1) production of cellulose acetate free from combined sulfuric acid (B. P. 357,893); (2) a ripening process for preparing cellulose acetate (B. P. 568,098); (3) acid treatment to improve dyeing properties of nylon (B. P. 568,092); (4) investigation of the possibility of using cationic soaps in dyeing nylon with direct cotton dyes; and (5) manufacture of alginate rayon (B. P. 567,641). A. L. Merrifield

Text. Research J. July 1946

Progress in rayons and textile auxiliaries. Anon. *Silk and Rayon* **19**, 1337–40 (Dec. 1945).

A brief discussion is given of the following subjects: (1) manufacture of methyl cellulose films and fibers (B. P. 569,878); (2) coating of fabrics with cellulose acetate (B. P. 569,979); (3) a method for producing stretched acetate rayon (B. P. 569,669); (4) a dry-spinning method for producing protein rayon (B. P. 569,662); (5) quantitative determination of carbon bisulfide in the manufacture of viscose rayon; (6) reducing the water imbibition of regenerated cellulose (B. P. 569,818); and (7) production of new ethylene polymers (B. P. 569,527). A. L. Merrifield

Text. Research J. July 1946

Progress in rayons and textile processing. Anon. *Silk and Rayon* **20**, 35–8 (Jan. 1946).

A brief discussion is given of the following subjects: (1) protecting colors on acetate rayon against gas fumes (B.P. 569,557); (2) production of crimped viscose rayon fibers (B.P. 570,159); (3) atmospheric oxidation of cellulose; (4) hardening of casein rayon filaments (B.P. 502, 710); (5) new catalyst for crease-resistant finishes (B.P. 562,790); and (6) lubricants for textiles (B.P. 569,701). A. L. Merrifield

Text. Research J. July 1946

Progress in rayons and textile processing. Anon. *Silk and Rayon* **20**, 161–4 (Feb. 1946).

A brief discussion is given of the following subjects: (1) application of vat dyes by padding methods (B.P. 571,325); (2) use of cyanamide for protecting anthraquinone dyes on acetate rayon from coal gas fumes (B.P. 571,056); (3) the future of finishing; (4) softening and lubrication of rayon fabrics with cation- and anion-active agents; (5) flameproofing of viscose and other rayons (B.P. 569,040); (6) process for permanently stiffening cellulose fibers; and (7) nylon fibers and films stabilized towards high temperature (B.P. 568,688). A. L. Merrifield

Text. Research J. July 1946

Plastic Structural Material

Holoplast. Anon. *Brit. Plastics* **18**, 14–20 (Jan. 1946).

"Holoplast" is the trade name for a new and unique plastic structural material. It is prepared from a special kind of kraft paper impregnated with phenolic resin. From this, laminated tubes are formed which are then cold-pressed to rectangular shape. These are laid side-by-side on a number of flat sheets of impregnated paper and, after being covered with more paper, are cured in a hydraulic press using removable inserts to prevent the collapse of the rectangular tubes. The boards can be finished in many ways, including the application of wood veneers. Data are given on the structural properties of the boards, and illustrations show some of their applications. E. F. Evans

Text. Research J. July 1946

Polymer Research

Recent progress in polymer research. H. Mark. *Record of Chemical Progress* **7**, 26–31 (Jan.-Apr. 1946).

A brief review of articles which appeared during 1945 in the field of fundamental high-polymer research. Includes papers on synthetic fibers, protein structure, etc. 116 references.

Text. Research J. July 1946

Recent Work in the Field of High Pressures

Recent work in the field of high pressures. P. W. Bridgman. *Rev. Modern Phys.* **18**, 1–93 (Jan. 1946).

The purpose of this review as stated by the author "is to summarize work in the field of high pressures which has been published in accessible form between" 1930 and 1945. He has restricted the field of study principally to those pressures measured in thousands of atmospheres. The review is divided into 8 main sections, namely: mechanical, thermal, electrical, magnetic, optical, chemical, and biological effects of high pressures and technique. The section on technique includes extension of the pressure range, measurement of pressure, and miscellaneous technique. The section on mechanical effects is subdivided into: volumetric effects in gases, liquids, and solids; phase changes in single and multicomponent systems; the effect of pressure on viscosity of gases and liquids, elastic constants, and plastic flow, as well as other miscellaneous mechanical effects. Thermal effects of high pressure include the effect on specific heat. The electrical effects include change of resistance of solids and solutions and change in dielectric constant. The sections on chemical and biological effects of high pressures are not classified. 674 references.

Text. Research J. July 1946 T. J. Dietz

Purification of Steam

Modern methods of producing clean, dry steam. C. H. S. Tupholme. *Silk and Rayon* **19**, 1111–12 (Oct. 1945).

A brief discussion is presented of the causes of steam contamination and methods of cleaning and drying steam. Steam purifiers fall in 2 general groups: (1) removal of solids by changes in the direction of flow, such as baffles, centrifugal separators, and turbo purifiers, and (2) washing the steam by contact with the boiler feed water followed by drying in various types of separating devices. A. L. Merrifield

Text. Research J. July 1946

Rayon Imports in Australia and New Zealand

Rayon trade prospects in New Zealand and Australia. Anon. *Silk and Rayon* **19**, 1349–50, 1353 (Dec. 1945).

A résumé of useful information for traders interested in the New Zealand and Australian markets for rayon goods, contained in the report of the British Rayon Federation's delegation to these Dominions, is presented. 5 tables are given: (1) New Zealand imports of woven rayon piece goods (1938–44); (2) New Zealand imports of woven cotton and rayon piece goods (1940–44); (3) New Zealand imports of knitted rayon piece goods (1938–44); (4) Australia's imports of woven piece goods of rayon or rayon and cotton mixtures (1938–43); and (5) Australia's imports of rayon yarn (1938–43).

A. L. Merrifield

Text. Research J. July 1946

Rayon Manufacturing Costs

Economics of viscose rayon manufacturing. Paul W. Frisk. *Rayon Text. Mo.* **27**, 69–71 (Jan. 1946).

The rapidly increasing demand for viscose rayon filament yarn has been due to low production costs and high quality, both brought about by research and developmental activities, and to the adaptability of this material when combined with cotton, wool, and other textile fibers. Expanded production of filament yarn of the same fineness as silk is predicted. Investment cost of viscose rayon yarn plants is stated to have increased from 80¢ per lb. per yr. in 1934 to $1.00 per yr. in 1938, and from $1.50 to $1.80 since 1944. Equipment now on sale by the government, such as boilers, compressors, and pumps, might appreciably reduce the cost of a new plant. Present production costs for viscose rayon are held to be the lowest in history despite rising labor costs, because of decreasing raw material costs and more efficient mechanical processes and chemical techniques. A decline in the price of 150-den. viscose yarn from 55 to 51¢ per lb. to 45–48¢ per lb. is predicted by 1950. R. B. Evans

Text. Research J. July 1946

Rayon Statistics

Rayon went to war: Control of production facilities. J. Guthrie Oliver. *Silk and Rayon* **19**, 1274, 1277–8 (Dec. 1945).

A discussion and a comparison of the production, consumption, and uses of rayon during the war are given. 6 tables are presented: (1) estimated world production of rayon (years 1939, 1942, and 1943); (2) United Kingdom production of rayon (1938 through Sept., 1943); (3) United States production of rayon (1939 through June, 1945); (4) Canadian production of rayon (1939–44); (5) world imports of rayon yarn (1940–45); and (6) world imports of rayon and mixture fabrics (1940–45). A. L. Merrifield

Text. Research J. July 1946

Water for Rayon Plants

Treatment and preparation of water in rayon textile mills. William S. Habbart. *Rayon Text. Mo.* **27**, 579–81 (Nov. 1945).

Water for rayon plants must be free of iron, magnesium, silica, manganese, and coloring matter. As about 70 lbs. of water per lb. of yarn are required, the amount of water to be treated is quite large. Details are given of the method of treatment used at the American Viscose Corporation's Front Royal, Va., plant. E. G. Martin

Text. Research J. July 1946

World Rayon Trade

World import trade in rayon yarn and fabric. J. Guthrie Oliver. *Silk and Rayon* **19**, 1122–3 (Oct. 1945).

Information on the imports of rayon yarns into all countries from 1937 to date was presented in the previous issue and this information is now completed by tables in

which are summarized the imports into all countries of rayon and mixture fabrics. 3 tables are given, as follows: (1) imports of rayon fabric into various countries of the British Empire, (2) the returns of imports for those foreign countries which have published figures since 1942, and (3) the summary of information for those countries which have not published recent data.

A. L. Merrifield

Text. Research J. July 1946

Research

Trends in textile research. Frederick T. Pierce. *Textile Bulletin* **70**, 102, 104, 106, 108 (Mar. 15, 1946).

A summary of some of the accomplishments in textile research in the past few years. The need for cooperative research to develop marketable products from present fibers and for further development of processing is stressed. Work done by the Shirley Institute is described briefly and praised. The accomplishments are said to be an example of what can be done in this country.

H. J. Burnham

Text. Research J. July 1946

Resistance Preheating

Resistance preheating of molding materials. C. G. Phillips. *Brit. Plastics* **17**, 527–8 (Dec. 1945).

Graphite is incorporated into a wood-filled, phenolic molding material to make it a partial electrical conductor so that application of sufficient voltage will raise the temperature of the molding material. The method is applicable only when color and electrical properties are not important. E. F. Evans

Text. Research J. July 1946

Rosin Soap

Use of modified rosins in soap. B. S. Van Zile and J. N. Borglin. *Oil and Soap* **22**, 331–4 (Dec. 1945).

Advantages of rosin modified by hydrogenation, dehydrogenation, or polymerization over ordinary rosins when used in soap are given. Modified rosins are not as susceptible to oxidation; therefore, they darken less. They increase the solubility of soap to a greater extent and show a slight advantage on the amount and stability of the lather. A greater germicidal activity is also exhibited.

Text. Research J. July 1946 E. Dermaner

Rubber Developments

Rubber developments in 1945. A. E. Boss and R. W. KixMiller. *Chem. and Eng. News* **24**, 336–7 (Feb. 10, 1946).

A review. No references.

Text. Research J. July 1946 E. F. Evans

Shuttle Furring

Shuttle furring and yarn tensioning. H. E. Wenrich. *Rayon Text. Mo.* **27**, 582–4 (Nov. 1945).

A comprehensive outline of these 2 subjects is offered for the guidance of fixer-learners. E. G. Martin

Text. Research J. July 1946

The Silicones

The silicones—truly new materials. Harold A. Knight. *Materials and Methods* **22**, 1069–73 (1945) (through *Chem. Abstr.* **40**, 764[7] (Feb. 10, 1946)).

Properties and uses of silicones are given.

Text. Research J. July 1946

Safety Switch for Motors

Automatic protective gear for A.C. motor starters. Anon. *Silk and Rayon* **19**, 1114–5 (Oct. 1945).

Starters for practically all motors, except, possibly, fractional horsepower motors, should be fitted with a low voltage release, often termed a no-volt coil, which trips the starter in the event of supply failure, and thus prevents the motor's restarting itself when the power supply is resumed. Several types of low voltage releases are described, including an electro-magnetic coil which is energized by current passing the coil when the starter is in the running position and automatic types which are energized by a control button, multiple positions, thermal trips, and special protection for 3-phase Delta motors.

A. L. Merrifield

Text. Research J. July 1946

Swiss Textile Machinery

Swiss automatic winders and looms. D. R. H. Williams. *Text. Mfr.* **72**, 23–5 (Jan. 1946).

Visits to the Swiss manufacturers of the Schärer automatic pirn winder, the Sulzer loom, the Saurer loom, the Ruti loom, and the Brügger pirn winder are described. Very brief and enthusiastic descriptions of the various machines are given. H. J. Burnham

Text. Research J. July 1946

Modern Swiss textile machinery. Anon. *Text. Recorder* **62**, 48–9 (Aug. 1945).

Four Swiss textile machinists have united to carry out their publicity by establishing a showroom designed to display their products and for the purpose of instructing foremen and technical students from all countries. A list and description of the products manufactured by the 4 companies are presented.

A. L. Merrifield

Text. Research J. July 1946

Tantalum

The use of tantalum in heat-recording devices. C. C. Downie. *Silk and Rayon* **19**, 1096–7 (Oct. 1945).

Tantalum tubing is used for a number of purposes in the production of rayon and other man-made preparations for heat-transfer applications, in the form of candle-heaters, helical heat interchanger coils, sheaths for electric heaters, and for certain immersed heat-recording devices. Although the initial cost is high, this is overcome by the good heat-transfer, high strength, and good corrosion resistance of tantalum. This metal is employed only where necessary. Tantalum is worked in a manner similar to nickel; however, care must be taken in the specifications for fabrication as re-melting difficulties make the scrap value extremely low.

A. L. Merrifield

Text. Research J. July 1946

Textile Show

Show in print. Anon. *Textile World* **96**, 101–16, 248 (Mar. 1946).

Brief discussions of equipment said to have been planned for the textile show in Greenville this spring, which was cancelled. Several pictures are included. H. J. Burnham

Text. Research J. July 1946

Winders and Twisters

Winding, doubling and twisting of rayon and silk yarns. Anon. *Text. Recorder* **62**, 46–8 (Dec. 1945).

A doubler-twister, a high-speed winder, and a rayon crepe twister are described. These machines have had some structural alterations and added refinements that render them easier to operate and supervise. At the same time, the production capacities have been increased. Changes have been made in the spindles, rings, traverse motion, feed rollers, detectors, and creel of the doubler-twister. The winder is of new design featuring package winding at a constant speed. The rayon crepe twister has spindles designed for 3-lb. packages, 2 decks, and can be had with either a headless or bobbin take-up package.

A. L. Merrifield

Text. Research J. July 1946

Wool Fabric Exports from England

Export angles of Britain's woolen-worsted industry. David Skalka. *Foreign Commerce Weekly* **21**, 11–13, 43 (Dec. 29, 1945).

Before the war, England exported from $\frac{1}{4}$ to $\frac{1}{3}$ of her production of wool fabrics, and wool manufactures comprised 10% by value of the United Kingdom's total exports in 1937. Employment was reduced by half during World War II and exports of wool fabrics, like domestic consumption, are still drastically rationed. Wages in England's wool manufacturing industry now average 32.5¢ per hr. as compared with 87.7¢ in the United States, and wool prices are lower than in this country, but output per worker in 1937 was 1,760 sq. yds. as compared with 3,380 in the United States. Tables give import duties on wool fabrics of various countries and data on exports of wool fabrics from the United Kingdom and into the United States. R. B. Evans

Text. Research J. July 1946

Wool Futures Trading

Wool. Anonymous. New York, Merrill, Lynch, Fenner and Beane, Mar., 1946. 64 pp.

This elaborate booklet discusses future trading in wool and gives background information on this important commodity. Trading in contracts for future delivery of wool tops is stated to have begun in the country on May 18, 1931, and in wool futures contracts on Mar. 17, 1941, at the New York Wool Top Exchange. Ways in which a futures market can be used to advantage by growers, merchants, and manufacturers of wool are described in detail. Wool merchants use future contracts mostly for hedging, but also to speculate on anticipated rises and falls in wool prices. Wool manufacturers use the futures markets mainly to cover requirements against sales for forward delivery, and to protect their inventories against price declines. The basic grade of wool for delivery on futures contracts at the New York Exchange is 64s wool shorn from living animals in the United States, but wools of 60s or finer grade, U. S. Standard, grown anywhere, and uniform pulled wool taken from the main body of the skin are also tenderable. The basic wool top grade conforms to grade 64s of U. S. Standards. The principal fact of wool economics at present is the surplus accumulated during the war as a result of stoppage of shipments to Continental Europe and Japan from the British Dominions and Latin America. Efforts of the British Empire and the United States to cope with the wool problem are summarized. A glossary of terms used to describe wool, information on trading hours, contract units, commission rates, and deliverable grades at wool futures exchanges, and statistics on wool supply and distribution, are given in the appendix. R. B. Evans

Text. Research J. July 1946

Wool Research

Wool industry research in the war years. Anon. *Text. Mercury and Argus* **114**, 403, 405, 407 (Mar. 22, 1946).

An outline of work done in England by the Wool Industries' Research Association at Torridon. Shrink-resistant finishes, warm clothing, pile fabrics, flotation clothing, medical filter cloths, waterproofing, felts, textile oils, milling investigations, drawing and spinning efficiency, fuel economy, protein analysis, and wool production are listed, but details as to accomplishments are lacking. H. J. Burnham

Text. Research J. July 1946

Wool Waste Liquors

Sulfide wool wastes endanger sewer system. A. M. Rawn. *Sewage Works Eng. and Munic. Sanit.* **16**, 491–3 (1945) (through *Chem. Abstr.* **40**, 659[6] (Feb. 10, 1946)).

Wool wastes containing soluble Na_2S mixed with sewage produced H_2S in sewers; this resulted in odor nuisances and the H_2S on oxidation destroyed concrete pipe joints in Los Angeles sewers. The company tried to reduce soluble sulfides with addition of $ZnSO_4$; this proved too expensive. Concentrated rinse was returned for re-use and the remainder was treated with $FeSO_4$. The value of Na_2S salvaged exceeds the cost of neutralization.

Text. Research J. July 1946

Labor Contracts in Textile Mills

A digest of the union contract with New England mills. Frank A. Constangy. *Cotton* **110**, 106–109 (Jan. 1946).

Provisions of a recently signed contract between the Fall River Textile Manufacturers Association, New Bedford Cotton Manufacturers Association, and the Textile Workers Union of America, with regard to union security, wages, work loads, seniority, and grievances are summarized. R. B. Evans

Text. Research J. July 1946

Review of Textile Developments

Developments in textiles in 1945. Milton Harris and Gypsy Frankenberg. *Chem. and Eng. News* **24**, 327–9 (Feb. 10, 1946).

A critical review. No references.
Text. Research J. July 1946 E. F. Evans

Chinese Textile Industry

Shanghai textile plants. Anonymous. *Foreign Commerce Weekly* **22**, 5, 23 (Jan. 26, 1946).

Approximately 750,000 persons depend on Shanghai's textile industry, which consists mainly of cotton mills but also has small wool and silk sections. Most of the industry was seized during the war and an undetermined number of mills were scrapped. Rehabilitation has been slow owing to shortages of raw material and power and to organizational difficulties. The current Chinese cotton crop is estimated at 1.1 to 1.5 million bales as compared to 2.4 to 2.6 million bales prewar.
Text. Research J. July 1946 R. B. Evans

Yugoslavia Textile Industry

Textiles in Yugoslavia. Emil Kekitch and Dorothy E. Kennedy. *Foreign Commerce Weekly* **22**, 6–9, 40 (Jan. 12, 1946).

Under tariff protection, the textile industry of Yugoslavia grew until in 1940 it included 150 mills, representing an investment of $36,000,000, employing 70,000 workers and producing goods valued at $50,000,000. Roughly 84% of the domestic demand for textiles was met by the industry. About 30% of the prewar capacity was destroyed during the war, and it is believed that some time will be required to regain 1941 production levels because of the loss of technicians and lack of equipment and transportation. The situation in each branch of the industry is analyzed. Yugoslavia is stated to be a potential market for American textile machinery if certain conditions are met. R. B. Evans
Text. Research J. July 1946

PATENT REFERENCES

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Ethyl Cellulose

Production of ethyl cellulose. Henry Dreyfus. U. S. 2,381,972 (Aug. 14, 1945).

This invention is concerned with improvements in the production of cellulose ethers, particularly ethyl cellulose. The process includes etherifying cellulose materials with di-ethyl sulfate in the presence of sodium hydroxide and of at least 40% of tetra-ethyl ethylene diamine, calculated on the weight of the cellulose material. E. G. Martin
Text. Research J. July 1946

Crepe Fabrics

Method of producing textile fabric. Cyril M. Croft, Walter H. Hindle, and Robert W. Pinault (to Celanese Corp. of America). U. S. 2,391,950 (Jan. 1, 1946).

An inexpensive method is described for the production of novelty fabrics such as crepes or seersuckers without the use of special high-twist yarns. The effects are produced by the use of yarns of thermoplastic material along with yarns of non-thermoplastic material in such a way that when the fabric is stretched and dried under tension, a crinkled effect will result when the tension is released.
Text. Research J. July 1946

Iodized Fabrics

Iodization of textile fabrics. Charles Rudolph Hans Ritter. U. S. 2,390,391 (Dec. 4, 1945).

The object of the invention is to provide a process for impregnating all kinds of textile fabrics with any fixed dose of free and active iodine in such a manner that the fabric can give off substantially its full content of iodine when it is moistened in water or any other suitable liquid.
Text. Research J. July 1946

Coated Textiles

Process of making coated textile materials and the articles produced therefrom. Ralph T. K. Cornwell (to Sylvania Industrial Corp.). U. S. 2,390,780 (Dec. 11, 1945).

By the process described it is said that a substantial reduction in the usual number of coatings required to cover the textile may be obtained.
Text. Research J. July 1946

Fiber Treatment

Apparatus for liquid treatment of fibrous material. Edward Knight (to American Viscose Corp.). U. S. 2,391,096 (Dec. 18, 1945).

An improved method for continuous treatment of fibers in successive stages through various treating liquids. Good penetration, no agitation of the material, no mixing of the liquids, and recovery of the excess treating liquid are among the features of the apparatus.
Text. Research J. July 1946

Pattern Effects

Fabric and process of producing it. William H. von Glahn and William L. Walsh (to General Aniline & Film Corp.). U. S. 2,390,903 (Dec. 11, 1945).

Pattern effects may be produced by weaving a fabric in which certain yarns have been chemically treated in such a manner that they will disintegrate upon heating, leaving the untreated yarn to form the desired pattern.
Text. Research J. July 1946

Carbonizing Wool Mixtures

Recovery of wool from mixed wool-cellulose acetate textiles. George W. Seymour and George C. Ward (to Celanese Corp. of America). U. S. 2,393,712 (Jan. 29, 1946).

The process described in the patent is said to effect complete removal of cellulose acetate, or other organic esters of cellulose, by employing in the carbonizing bath an organic swelling agent such as ethyl alcohol. This causes the cellulose acetate fibers to swell and enables the acid of the carbonizing solution to penetrate. Subsequent baking results in complete carbonization.
Text. Research J. July 1946